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Q&A Hoyt Yeatman

INTERVIEW BY E.T ELLE SHAY



INTERVIEW BY ESTELLE SHAY

There was a time, back in the pre-digital era, when one could easily tick off the names of the small cadre of practitioners who formed the core of the visual effects business in Hollywood — dedicated young wizards whose boundless talent, grit and determination helped to nudge the transitioning industry into the 21st century. Among those now-veteran trailblazers is the still boyish-looking Hoyt Yeatman, Academy Award winner and co-founder of Dream Quest Images, one of the handful of effects facilities that dominated the industry in the eighties and nineties.



For Yeatman, it all began with *Close Encounters of the Third Kind*, on which the budding effects artist, still a student at the UCLA film school, managed to wrangle a job working the graveyard shift, babysitting all-night light passes on the alien mothership that took up to seven minutes per frame. After graduation, he worked for Robert Abel & Associates on some of the era's most innovative television commercials before joining the Universal Hartland facility as a motion control cameraman on *Buck Rogers* and *Battlestar Galactica*. His feature film career kicked into gear when Douglas Trumbull hired him to work on *Star Trek: The Motion Picture*. Soon thereafter, Yeatman and five other young innovators formed Dream Quest Images, operating first out of a residential garage, but soon graduating to a small commercial building in Culver City — and later a large studio complex in Simi Valley — as assignments came flooding in.

Over the next two decades, Yeatman went on to grander achievements, contributing to more than a hundred films, television shows and commercials that featured some of the most memorable and groundbreaking effects of the day, and winning an Academy Award for his work on *The Abyss*. Other early projects included *Blade Runner*, *The Adventures of Buckaroo Banzai* and *Blue Thunder*. In 1996, Yeatman and his partners sold Dream Quest to Walt Disney Studios, where it was absorbed into the studio's features animation division and later renamed The Secret Lab. Under the Disney banner, Yeatman honed his digital skills on such high-profile movies as *Armageddon*, *Mission to Mars* and *Mighty Joe Young*, for which he earned a second Oscar nomination and an Academy Technical Achievement Award for developing the film stock Kodak SFX200T. But three years later, with little fanfare, Disney shuttered its digital production facility, and for the first time in a very long time Yeatman was a man without a company.

Quietly operating under the radar since then, Yeatman has by no means been resting on his laurels. In a recent chat with Cinefex, he filled us in on what he has been up to since leaving Disney, and what he predicts the future has in store, both for the industry he helped shape, and for him personally.

Having built Dream Quest into one of the most respected visual effects companies in the business, it must have been terribly disappointing to witness the demise of its successor. Ever give any thought to what would have become of you and/or Dream Quest if you hadn't sold the company?

It was at a time of transition. Apogee was out of business, Boss Film was going down. We had done some analysis with business people we had brought in, and what we found was that we could not keep up the input into the technology. Sony, IBM and Lucasfilm were putting millions of dollars into their facilities at Imageworks, Digital Domain and ILM. We knew that unless we had some kind of infusion of money, we could not have made that leap. We would have slumped back and fallen behind the curve. Luckily, the opportunity with Disney came up, and they were into digital technology and this new kind of filmmaking, and I really believed we could help them, creatively and technically.

Can you elaborate on what led up to Disney's decision to shutter their digital animation studio after such a huge infusion of capital and equipment had gone into its setup?

The whole structure over there was changing. The economy and market were changing for Disney, too. They didn't just close us. They had a whole paradigm shift. They decided to focus on the internal creative. I thought: 'They're going to need product in the future, and the only way to survive is to elevate myself to be that person who is creative and driving the front end.' I'd hoped they'd be my best friend at the end of the day, but in a very different relationship.

After you completed Kangaroo Jack, you left Disney and set up your own production company, Whamaphram Productions, with your longtime producing partner, David James, to develop new animation projects. What made you decide to switch gears and move in that direction?

Around the time my tenure at Disney was ending, I really began thinking about what the future would be. I loved doing what I was doing, but I could see that the world had changed — not just at Disney, but across the board. Probably like any other high tech industry in the U.S. today, the visual effects business is faced with outsourcing. That's just a reality. I think it stems from a certain perception of how the studios and how filmmakers view visual effects in general. Effects are a commodity now. Visual effects animation is still slightly unique, and there are fewer groups around the world that can actually do character animation correctly, but nonetheless it's still looked at as a postproduction effect and something that you go out and get when you're thinking about making a movie, as opposed to embracing it as a process that you'd want to keep and develop internally within the company. That's just the corporate culture.

It's sad, because when I look at that compared to, say, the Electronic Arts people who are doing game design, I see a big difference. Unlike game designers, who came in with a very different attitude, the studios do not see us as creative partners in the process. Yet when you look at the contributions that visual effects are now making to most of the bigger effects films — they're huge. Not just technically, but also creatively. So when I left Disney, I sat down and said, 'Look, I have a bunch of ideas — I want to develop them.' My thought was rather than going right back into visual effects, I would take a year and a half off at my own expense and do that — which I did. And since I was still thinking in terms of having a company, David and I formed Whamaphram.

One of those ideas was a concept for a rather unique family adventure film called *G-Force* — now in development at Disney — a project you hoped would allow you to transition from visual effects into directing. Can you tell us more about that?

A number of visual effects supervisors are now making the transition into directing — some successfully. But I figured the only way I was going to get there was to kind of break the mold of animation and point it in a new direction, convince a studio that this is something sound to do, with commercial potential as a franchise — which is what they ultimately want.

You refer to *G-Force* as a ‘hybrid’ film. Explain what you mean by that.

By ‘hybrid,’ I mean that there are actors in it, but the world really revolves around the CG characters. The main one is an enhanced guinea pig who works as a covert agent at a top-secret facility of the U.S. government. He’s kind of a fish out of water — small hero, big adventure — and there’s a whole world we’re creating. I want to use advanced photogrammetry technology, virtual set technology — techniques that would give me freedom in images and ways of doing things. It’s a concept that doesn’t fit neatly into either camp — animation or visual effects.

How did you pitch it?

Well, that was an experience unto itself. You come up with an idea, you come up with a cast of characters, you do the artwork, you do the story — and in this case we did an elaborate one-minute teaser — you put it under your arm and take it around town saying, ‘This is what I’d like to do,’ and people look at it. But even though I think they were interested, it was just too new. It wasn’t a proven idea like from a book or comic. And I was a new director, with a new concept, new ideas.

When did you first start shopping it around?

About two and a half years ago. We went around to all the big studios who’d done animated films. We went out with it as an animated project, as indeed it is. All the main characters in the film are driven and storied by the animation. But I found out very quickly that the bigger facilities that are doing animation have their own internal development divisions and really didn’t want to muck about with my idea. So it was pretty much a dead end.



*Visual effects supervisor Hoyt Yeatman was a founding partner at Dream Quest Images, one of a handful of companies that dominated the visual effects landscape of the eighties and nineties. After Dream Quest was absorbed by Walt Disney Studios in 1996 and eventually shuttered in 2001, Yeatman set out on a new course, developing creative content for motion pictures — commencing with *G-Force*, now under development by Jerry Bruckheimer Films. Attached as director, Yeatman examines a foamcore set mockup created by the art department.*

Then I went back and relabeled it as a visual effects film, as indeed it also is. Nothing else changed, really, but that opened up the market to a larger group. Jerry Bruckheimer's group, which is where it was eventually purchased, loved it. The timing was perfect. Jerry wanted to create family entertainment; and being that he's so visual effects oriented, he understood the hybrid quality of it. I've known Jerry for several years now, having worked as a visual effects supervisor on several of his shows, and he has traditionally always looked for things that are new and on the cutting edge and different. He sees a bunch of creative people and says: 'I want to do this.' And the great thing about his group is that they have no preconceived idea of how it should be done, which is very liberating. Jerry has vision and is super-supportive.

Was there a screenplay attached to the project at that point?

No. Jerry's group bought the concept with the idea of developing it internally — which is actually a very positive thing. We turned in a 30-page 'scriptment,' which had all the character designs and a full story, but I did not attempt to write the script because I knew the way the process was going, that they would hire writers.

Did you have creative input?

Very much so. I met with the writers about eight times. They got the scriptment, and kept pretty close to the main core of the story, adding a couple of things to make it better. At that point, I was saying, 'Okay, we have a script — now what?' But they were busy working on other projects, and there was a regime change at Disney — it was in limbo. Then about two months ago I got a call from the Bruckheimer group saying: 'Come down. We're making your movie.' They were ready to take it to the next step — which is to say, to develop the script visually, bring on a production designer, and start looking at how the film could be accomplished.

Does that mean G-Force has been greenlit?

It's more like a blinking yellowy-green. We've got two big buildings at Culver City, and we've been given the greenlight to acquire three stages. We have about forty people on staff, including five storyboard artists who have already boarded a good part of the picture — so I have a pretty sizable army right now. It's really a cooperative, evolutionary process, and it's very exciting when things begin to gel.

While G-Force was on the back burner, you accepted a freelance gig supervising visual effects for Underdog. How did that come about?



*Operating first out of a residential garage, then a small commercial building, Dream Quest eventually expanded into a spacious studio in Simi Valley. During production of *The Abyss*, members of the Dream Quest visual effects team prepare to shoot a dry-for-wet miniature of a sunken nuclear submarine on a massive motion control gantry stage constructed at the Simi Valley facility. Yeatman won an Academy Award for his work on the James Cameron deep-sea thriller.*

Once the Bruckheimer group bought our concept for G-Force, I realized that I really had absolutely zero control at that point, zero ability to move it forward because it's not like a live-action show that has a release date. So you just put it on its course and it sails off into the sunset, and you cross your fingers and hope. But then I thought: 'Oh my God! I've got to get back to work and earn a living now!' Fortunately, a good friend of mine, Frederick Du Chau, whom I've known in years past because he worked for a while at Dream Quest, was directing Underdog, and asked if I would be interested in supervising the visual effects. I loved that the characters were both real and CG, which was right up my alley, so I found myself back at Disney.

This was your first assignment as a freelance effects supervisor working on the production side. What was that like?

Well, it was interesting, because we knew from the get-go that all the visual effects on Underdog, for mostly economic reasons, were going to be done overseas — the outsourcing I had predicted I was now experiencing first-hand. I looked at what tool sets we had at the studio to work on a project that wasn't a *Pirates of the Caribbean* film, that didn't have millions of dollars to spend on interconnectivity and that whole process, and I realized that the studio was not really well-suited to do an animated film overseas because up until then they hadn't needed to. So a lot of my energies were spent setting up databases within Disney so that we could actually work on a global project, setting up communication lines and systems to make that happen on a cost-effective basis. They embraced the new technology and are using the systems on other projects now. The process for me was very different, since I'd been used to walking in the trenches, and now I had to supervise from afar and look at the bigger picture. But both of the vendors who handled the bulk of the work — Cinesite London and Framestore CFC — did an amazing job. The muzzle replacement work that Cinesite did is probably some of the best that's been done, and Framestore's CG dog was so cool we ended up taking a lot more of the shots into the 3D world than we had originally planned on.

Now that Underdog is in release, and G-Force looks like a go, does that mean you're out of the visual effects business?

I'm not getting out of visual effects. I still love it. And operating in the creative mode is always risky. I hope my first attempt to direct is successful; but if it is, people will probably wonder if it was a fluke. So I'm keeping my finger in the pie. I'm even exploring new technologies. I've developed a device called HDR Cam — a computer controlled lighting capture system that captures the lighting dynamics on a set or location. That information can then be used to light the CG. We used it on Underdog, and it made a huge economic difference. Plus, I liked the realism that it brought. You're



Among the films assigned to Dream Quest Images after its acquisition by Disney was the 1998 remake of Mighty Joe Young. Yeatman received a second Oscar nomination for his work on the show, and earned a Technical Achievement Award for the development of a new film stock. Yeatman and his crew continued to create effects under the Disney banner, eventually moving from Simi Valley to merge with Disney's feature animation division, at which point Dream Quest became known as The Secret Lab. Yeatman remained there until 2001, when corporate restructuring led to the complete dismantling of the studio's in-house visual effects unit.

actually able to capture the lighting that the director of photography has done, or that you've gotten from natural locations.

Nothing like this currently exists?

I tried to rent or buy something like it, and there really was nothing on the market. So I designed it with my brother, Bob Yeatman, who does electronic programming, and Fred Iguchi from the old Dream Quest, who does hardware electronics. We built a prototype and went out and shot all of Underdog with it. Then we supplied both Framestore and Cinesite with it, and followed the project through post to see how well it was working. At the end, when I asked the guys at Cinesite how it went, they said, 'We went from six days to light a scene through traditional ways to about three hours.' So at that point, we built two more. What's neat is that these systems are made to travel, and we can access any of the cameras anywhere in the world as long as there's an Internet connection.



After the closure of The Secret Lab, Yeatman took on his first assignment as a freelance visual effects supervisor on the Disney comedy, Underdog, about a down-and-out hound imbued with extraordinary powers, who becomes a canine caped crusader intent on ridding the city of a villainous scientist and his minions. Yeatman farmed the visual effects work out to two overseas vendors – Cinesite, which handled muzzle replacements for the show's cast of talking dogs, and Framestore CFC, which produced shots requiring a CG version of the canine superhero.

As you look back on your years in the visual effects 'trenches,' any final observations?

At Dream Quest we used to have a motto: 'The best idea wins.' It doesn't matter if it's a custodian who has the best idea. You go with it. And that to me is a philosophy that comes from the heart, comes from the top. That's how you run a company. I've found that when a group of people are having fun together, it shows up on the screen. And that's the difference. When you talk to most people at the bigger effects studios today, effects are not fun anymore. It's a lot of hard, grinding work, and then you're out. There's no family, there's no consistency. It's a corporate American model that's not very pleasant. And sadly, I don't see it getting much better.

Does that mean we're unlikely to see another Dream Quest?

Well, never say never, but right now I'm having fun. I'm thrilled to have gotten as far as I have with G-Force. To come out with an idea, go out there and actually sell it, get it written, get it embraced — to the point where I now have an office in a studio and things are happening — is a lifelong dream. I've got my fingers crossed, and I'm counting my lucky stars — and with any luck and persistence, it will happen.

Overview

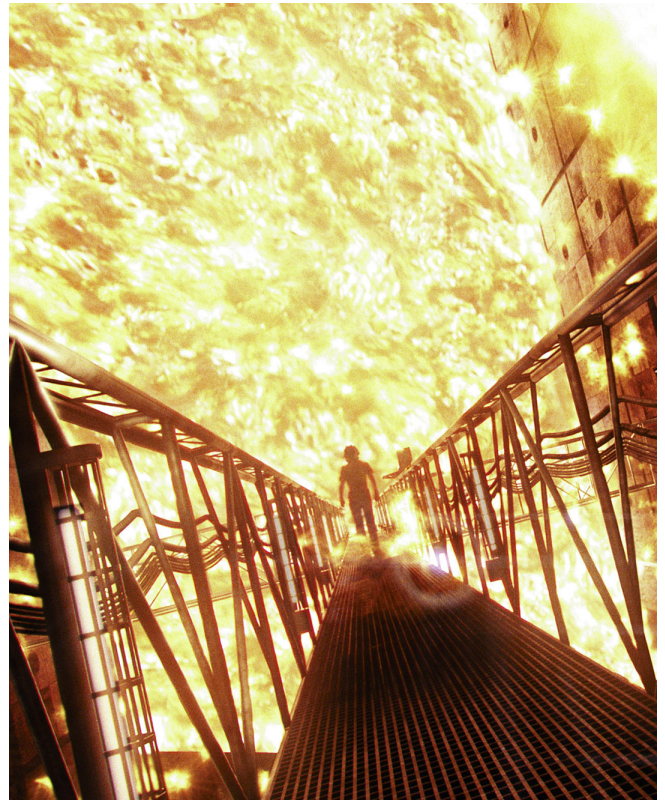
Tom Wood on Sunshine

Article by Jody Duncan

As the director of gritty, down-to-earth fare such as *Trainspotting* and *28 Days Later*, Danny Boyle was unaccustomed to finalizing his films by relying heavily on the talents of a postproduction visual effects team. So he was understandably reluctant to do so when it came to his newest project, *Sunshine* — even though, unlike those earlier releases, *Sunshine* was the type of science fiction space adventure traditionally laden with effects. As scripted by Alex Garland, *Sunshine* is set 50 years in the future, when all life on earth is threatened by the imminent death of the sun. To reignite the star and save the planet from extinction, a group of astronauts is sent to plant and detonate a massive bomb on the sun's surface.

In his earliest discussions with visual effects supervisor Tom Wood and visual effects producer Jo Nodwell — both from The Moving Picture Company, which would be the sole effects house on the show — Boyle expressed a strong preference for in-camera techniques, such as miniatures. Throughout preproduction and production, however, Wood presented Boyle with intriguing and suggestive previz that convinced the director to explore what digital effects technology could offer. “Danny hadn’t done anything before with this level or number of visual effects,” said Wood, “and he started out with a very fixed idea of what the film was and how he was going to achieve it. He wanted to do most of the film practically, because he is accustomed to playing with things in camera until he gets what he wants. He didn’t want to deal with the rigidity of visual effects, or their potential staleness because of all the pre-planning involved. He didn’t want visual effects shots that were non-organic, or seemed out of place with the rest of the film. So, I was quite conscious of avoiding all of those things in our previz. Our previz illustrated suggestions of shots, rather than complete representations, and Danny responded very well to that. As we went along and showed him these bits and pieces of previz, he started to embrace what visual effects could do for him.”

In its final form, *Sunshine* featured only a couple of miniature photography shots and 700 visual effects shots, which MPC integrated with live-action filmed on stages at London’s 3 Mills Studio. Images of the sun from various distances, as seen from the rescue team’s spaceship, Icarus II — a



massive construct surrounded by a mile-wide shield that protects the ship and its inhabitants from the sun's heat and radiation — comprised about a third of the visual effects shot count, while shots of the computer generated spacecraft and extensions of partial sets built by production designer Mark Tildesley and his art department accounted for the remaining two-thirds.

In keeping with Boyle's practical, in-camera preferences, the original plan had been to build and shoot miniatures as a means of realizing exterior shots of the Icarus II. "Initially, we were going to go with miniatures a lot of the time," noted Wood, "but due to the huge scale of this mile-wide ship, we would have had to build a large number of miniatures to represent it at different distances and to get the shots we needed. Even then, we wouldn't have been able to get all of the shots with miniatures. Some of them would have had to be CG, anyway. So we decided to go fully CG, which is what I was subtly pushing for from the beginning. Fortunately, that issue was resolved prior to the shoot."

The Icarus II started with an art department concept. Special effects supervisor Richard Conway and his crew translated that design into a maquette that featured brass plates forming the large gold shield at the front of the ship. Then MPC rebuilt the maquette as a computer model. "We changed the construction and layout of that maquette very little in the overall look of our computer model," recalled Wood, "but we made some changes for the sake of scale, basing the construction on existing physical buildings around us in London. There's a specific type of steel work you see in high-rise, glass-fronted buildings, and we added similar architectural detail to the ship. Behind the shield was an incredibly detailed mesh of interconnecting pipes supporting it. We also broke up the front so the shield wouldn't look like one big, static dish. Rather, it is made up of 90,000 individual panels measuring two by five meters each. Within the flight, these panels are constantly fluttering to compensate for the sun's bombardment of electromagnetic interference. They all articulate independently, and we had a particle system driving that movement."

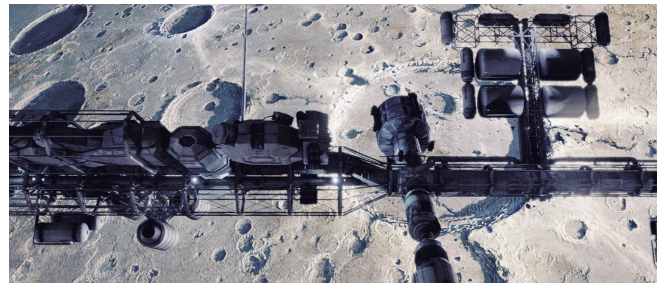
Maintaining a sense of massive scale in CG shots traversing the length of the vessel proved to be challenging. "We'd pick a previz shot or animate a new camera to show a progression from one point in the ship to another point in the ship — and we were just constantly thrown by the size of it. To travel across the ship and make any decent progress within a single shot, we'd have to move the camera so fast that the ship actually wound up looking like a miniature! A lot of the time we wound up cutting a single shot into two because it just wasn't going to work as one shot. The size of this ship was always problematic, but we gradually got used to it." Working with Wood and 2D supervisor Marian Mavrovic — who was responsible for the show's compositing pipeline — 3D supervisor Kieron Helsdon oversaw the building, lighting and rendering of the Icarus II.

MPC also extended partial sets representing specific interior or exterior sections of the Icarus II. For a scene in which crewmembers spacewalk onto the shield to repair some damaged panels, Mark Tildesley's crew built a small shield set — complete with mechanized panels engineered by the special effects department — on a stage at 3 Mills Studios. MPC then extended it in CG. "The set was very small, and had to double up for multiple sections of the shield we see as the two astronauts travel across it to get to the damaged panels. That turned into our biggest challenge in terms of integrating visual effects with live-action, because the set was incredibly reflective, due to the pieces of brass the art department had used to build the surface of it. The first time we walked on

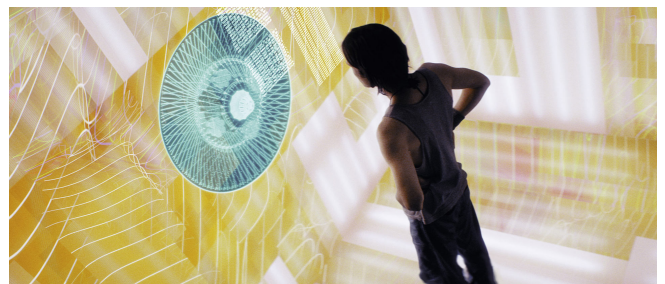
that set, we got a weird sense of vertigo because it was like walking on a mirror. You couldn't sense where the floor was, because of the reflection of the ceiling on the surface. To get away from that perfect mirrored look, Danny and Mark had a bunch of riggers come in with chains and smash up the surface of the set, breaking up the mirror surface by creating scratches and divots all over it."

The flat, mirrored surface of the ship's shield presented a similar problem in the CG version. "Our CG shield, of course, was being seen at a much greater distance away, and at that distance, scratches and divots all disappear, and you're left with a perfectly mirrored surface again. So we had to introduce much bigger scoring, representing damage from whatever the spaceship had flown through, to get that same distressed look on the surface."

Even with the distressed surface on the stage set, reflections abounded, requiring MPC to do a huge amount of rotoscoping. "The roof was painted black, but there were still a lot of reflected details that had to be removed. We had to replace everything above the set, and everything in the set, due to the reflections — and that resulted in a lot of people doing a lot of roto for a very long time." In addition to removing unwanted stage elements reflected in the set's surface, MPC had to remove wire rigs worn by the actors to make it look as if they were operating in a zero-g environment. "The wire rigs were more obstructive than usual, because the suits were so heavy and bulky; and so, none of them disappeared. They all had to be removed. Each wire was reflected, as well, so everything was doubled due to the mirrored surface."



Directed by Danny Boyle, Sunshine is set 50 years in the future, when the imminent death of the sun threatens life on earth. To jump-start the failing star, a scientific team is dispatched to within close enough range of the sun to launch and detonate a massive stellar bomb. The team's modular spaceship, the Icarus II – protected by a mile-wide reflective shield – performs a slingshot maneuver around Mercury en route to the sun. The Moving Picture Company – the sole effects vendor on the show – modeled a 3D Icarus II based on art department designs and a maquette provided by special effects supervisor Richard Conway.



After picking up a distress signal from the long-lost Icarus I – which had failed to complete its mission – Icarus II physicist Capa (Cillian Murphy) consults data within the ship’s holographic ‘Earth Room’ to determine the feasibility of a rendezvous in space. MPC inserted luminous schematic imagery into plate photography of Murphy standing on a small platform surrounded by greenscreen. Despite Danny Boyle’s preference for in-camera effects over digital, the film’s demanding imagery dictated a final slate of 700 visual effects shots.

The ship’s captain, Kenada (Hiroyuki Sanada), dies during the shield repair effort, when the ship’s computer inexplicably adjusts the spacecraft’s position so that the crew is in the direct path of the sun and is subjected to its full force. “The crew is working against the clock, trying to fix the last panel as sunlight is fast approaching and burning everything up. We had to create this wave of burnt material that rises up in front of the captain and consumes him. There are about three or four shots of the wave approaching him and breaking on him, and we worked on those shots for a very long time, creating the wave with multiple particle and surface elements in 3D.”

Later in the film, the space crew comes across the Icarus I — which carried members of the first doomed mission — lying dormant in orbit around the sun. The design for Icarus I, which was also built as a computer model, was based on the idea that there would be few differences between the first and second rescue spaceships, which, according to the narrative, were built consecutively, within a narrow time-frame. “The Icarus I ship was a bastardization of Icarus II, really. All we did was mix up the units, so they were in slightly different positions and configurations. We put the modules in a different arrangement, and then applied various distress maps to the whole ship to make it look older and broken and damaged. We modeled punctures and bits of damage to the framework that would make it look different, but not too unstable for the crew to go aboard. For scenes when the space crew goes in and explores the Icarus I, the art department just redressed existing Icarus II sets.”

Richard Conway and his crew built scaled versions of the airlock areas of both the Icarus I and the Icarus II for miniature photography shots of the two ships docking. “We had two quarter-scale miniatures of the airlocks, which were featured in two or three shots.” The production art department also designed and built full-size airlock sets for live-action filming.

MPC composited both CG and miniature ship elements against a computer generated space, which Boyle envisioned as a vast empty blackness. “Danny didn’t want to have stars visible in space. He wanted it to be black and claustrophobic. We pretty much stuck to that, although there were a few shots where we needed to see some stars, just to register that the camera was moving and not the ship. For



The ship’s physician, Searle (Cliff Curtis), is transfixed by an image of the sun on a screen in the Icarus II’s observation lounge. Production designer Mark Tildesley built the observation room as a full-size set, with a large greenscreen area for MPC’s sun images. Director of photography Alwin Kuchler carefully lit the set to create a particular quality of illumination emanating from the viewscreen’s solar imagery, while also serving visual effects requirements. Images of the sun, seen at varying

the most part, we rendered space to be slightly lighter than the blackest part of the ship; so the ship appears in silhouette against space.”

distances and intensities throughout the film, presented MPC with the show’s most challenging effects and required months of intensive research, including studies of observatory and satellite photographic material.

As the film progresses, the sun appears ever larger on the screen in the observation room of the Icarus II. The art department built the observation room as a full-size set on stage, which sported large greenscreens to provide matte areas for the final exterior images. “There were a lot of observation room sequences, where the cast would be looking at our inserted visual effects image of the sun in the final sequence. Not only would we be inserting the sun, but that sun also had to be a light source lighting the characters. The DP, Alwin Kuchler, and Danny wanted a particular type of light falling on the cast from that source; but, at the same time, I required that there be a greenscreen there so we could put in our sun relatively easily. We did some tests to experiment with different light options, and finally found something that would give Danny what he wanted but also serve the greenscreen requirements.”



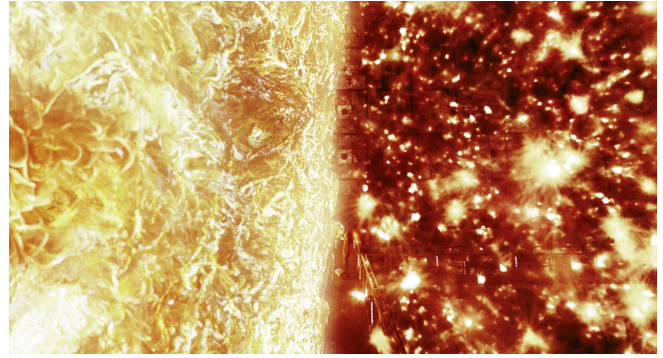
As crew deaths mount, and systems on the Icarus II begin to fail, the module containing the stellar payload is released on a sunbound trajectory. On board the hurtling module, Capa battles with the deranged commander of Icarus I – the sole survivor of the failed first expedition – who is attempting to thwart the mission. Mark Tildesley and his crew built a partial set on stage to represent the bomb module interior, which Danny Boyle filmed against greenscreen. MPC extended the set digitally and added dramatic lighting and atmospherics.

Creating the sun images inserted into the observation room sequences and other scenes presented MPC with its most challenging effects work on the show. Whereas producing images of futuristic ships in space was well-tread ground for the visual effects team, creating plausible and stunning shots of the sun — especially in proximity to camera — was virtually unprecedented. “I don’t believe there have ever been visual effects shots of the surface of the sun. This was a first. We had shots of the ship going into the sun, moving through multiple layers, all the way down to the surface. On top of that, we had two other categories of shots: distant shots of the sun, which is seen in its entirety within the frame; and then, as we get closer, we see shots of the partial sun with a horizon line. So we had these three different types of sun shots; and each required its own discipline and technique.”

To develop concepts for the sun images, Wood and his crew at MPC conducted extensive research. “We tried to find as much visual material as we could, raiding observatories and other sources. One of the observatories, called SOHO — Solar and Heliospheric Observatory — is a satellite that sits between the earth and the sun. That satellite watches the sun constantly, and you can download up-to-the-day views of the sun from it. It was a huge wealth of visual information for us. The SOHO images are defined in gamma ray and x-ray wavelengths, so you see a range of anomalies on the sun’s surface, such as huge turbulent storm systems. The other source was a Swedish telescope in the Canary Islands that constantly looks at the sun; and that’s where we got our images of

sunspots. We also looked at various National Geographic journals to see how the sun has been represented in the past, and how it has been visualized.”

Aesthetically, Wood was reaching for two divergent goals in the sun images: to create shots of the sun that would be familiar to audiences, but also create images of the sun as it had never been presented in a film. “Most of the time, we tended to go with images and sun characteristics that would be more familiar — such as the sun spots, which appear as black patches with spaghetti-like tendrils pouring into them. Other times, we combined those familiar sunspots with the very violent storm looks we’d seen in the SOHO satellite images. We had to show more of the sun than we’d ever seen before — at least more than lay people had seen before — and yet make it a recognizable sun. It had to be familiar to the film audience; and yet, it also had to be more animated and more layered than we’d normally see. On top of that, all of the sun images had to be relatively accurate, scientifically.”



In the film’s metaphysical finale, Capa rides the stellar bomb into the sun, encountering a massive wall of solar energy that sweeps through the module and pauses just in front of him. Capa reaches out to it, accepting his fate, and the bomb detonates, reigniting the dying star and saving earth’s inhabitants from frozen oblivion. For closeup views of the sun’s surface, Moving Picture Company generated procedural 3D displacement layers to create a violent solar landscape that echoed scientific reality.

In some instances, the shots also had to reveal the sun behaving in a particular manner, as conceived by Danny Boyle. “Danny wanted moments in which the sun would be a character, reacting in a very specific way. We talked about the sun’s being the tenth character in the film; but then, you can start talking about the ship’s being a character, as well — and suddenly you’ve got a huge ensemble cast! But there’s no doubt that the sun is a somewhat hostile presence in the film.”

MPC used Maya and RenderMan software to create the three categories of sun shots. The distant sun was made up of a geometric sphere, coupled with particle systems and fluid dynamics, generated by effects lead Greg King and integrated by compositing lead Stuart Lashley. Applying 3D, fluid-driven elements to matte paintings created the closer partial sun and descent into the sun views.

By presenting to the director intriguing but sub-tle previz images, Tom Wood and the artists at The Moving Picture Company piqued Danny Boyle’s curiosity and moved him from a stance dead-set against digital effects to one in which he was open to the possibilities of digital technology and how it might enhance his space thriller. “It was a long, slow seduction, basically,” concluded Tom Wood. “However, I don’t know that Danny is going to be ‘faithful’ in the future. He may very well go back to a practical approach!”

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Overview

Evan Jacobs & Patrick Tatopoulos on *Resident Evil 3*

Article by Joe Fordham

Filmmaker Paul Anderson and producer Jeremy Bolt first tackled Capcom Entertainment's videogame, *Resident Evil*, with a film adaptation in 2002. Written and directed by Anderson as a prequel to events in the game, the film traveled beneath a deserted mansion into a zombie-infested research laboratory owned by the nefarious Umbrella Corporation. The 2004 sequel, *Resident Evil: Apocalypse*, ventured above ground into Raccoon City, a fictional metropolis overrun by flesh-eating cannibals; and this year's *Resident Evil: Extinction*, explored the irradiated wasteland beyond Raccoon City. All three stories revolved around an Umbrella security operative, played by Milla Jovovich, a genetically modified superhuman soldier known simply as 'Alice.'

To create post-apocalyptic environments for the third film, the production selected desert locations in Baja California, followed by a studio shoot in Mexico City. Patrick Tatopoulos Studios supplied zombie makeups and practical creature effects and Mr. X, in Toronto, served as the digital effects vendor.

After a year in development, the project kicked into high gear for visual effects supervisor Evan Jacobs, who shared supervisory credit with Mr. X president Dennis Berardi and oversaw visual effects throughout principal photography. "There was a clean division of duties," said Jacobs. "I prepped the show, shot it, and handed over the elements. Then Dennis took the ball and ran with it."

Jacobs joined preproduction in Los Angeles, meeting with director Russell Mulcahy just a week before the production move to Mexico, then prepared previsualizations with Mr. X animator Jason Edwardh on location in Mexicali, planning shots that catered to the director's brief in the unforgiving desert environment. "Russell's directing style was very fluid, shooting from the hip," related Jacobs. "He comes from a music video background and likes to 'run and gun.' We almost always had three cameras running, many of them handheld, pointing in different directions to get the energy that he wanted to achieve."



One of the film's most ambitious shots follows an opening sequence in which 'Alice' is killed in what first appears to be Spencer Mansion — the Umbrella Corporation research facility established in the first film — and then tossed out into a desert trench filled with dozens of other discarded Alice clones. The production filmed the trench reveal on location in Mexicali, using motion control repeat passes to create the illusion of multiple Alice corpses. "It was 122 degrees Fahrenheit in the shade in Mexicali," stated Jacobs, "and we were planning to shoot Milla in the trench, first unit, with motion control. I called Camera Control in California, whom I've worked with off and on for a couple of years, and lead motion control operator Simon Wakley and his team brought their Milo rig out to location with 120 feet of track. They built the rig in a day, and we shot it the next day."

To create overlaps of corpses, the production positioned six Alice body doubles down the length of the trench, filmed in 18 passes. Last-minute scheduling made it impossible to include Jovovich among the doubles, so Jacobs and Camera Control filmed all of the visible Alice elements using motion control on a bluescreen set in Mexico City, aligned with Mexicali plates. “The shot started off with Milla in a non-motion-control crane move, shot on location,” said Jacobs. “We dollied back as two guys dropped her into the trench, and we tilted down. The whip-tilt transitioned into our motion control shot, with Milla rolling into frame, filmed on bluescreen in Mexico City. We then picked up the first pack of six girls; and the camera moved down the trench, with a little gap where we positioned Milla. We made our way along, layering the elements with a lot of rotoscope.” Mr. X created a seamless transition from the Milo move to a Technocrane shot that appeared to continue the pullback, slipping through a chain-link fence. “We started with our Technocrane right up to the fence and pulled out. Mr. X created a transition using a piece of a digital set and fence, and then transitioned into a reveal of Patrick Tatopoulos’ zombies outside the fence.”

Harsh conditions put demands on zombie makeups overseen on location by key special makeup effects artists Richard Redlefsen and Bruce Fuller. “We wanted to stay true to the style of zombies in the Resident Evil world,” said Tatopoulos, “but Paul Anderson and Russell Mulcahy asked us to find a color scheme that would work for zombies in the desert environment, so we came up with a sandy, dusty look.” The Tatopoulos team created six sculptures to depict lumbering ‘desert undead’ and a second breed with more aggressive tendencies, seen later in the film, known as ‘super-undead,’ depicted with a hairless, organic wet look based on a smoother sculpt. Foam lab supervisor Mark Viniello oversaw production of foam latex appliances in Los Angeles, which Fuller and Redlefsen used as a palette to create varieties of zombies. “We had a kit of multiple pieces. We could take the upper forehead of one, or lose the forehead of another, creating a pool of elements to create different characters. Bruce and Richard did most of the work through painting, sometimes creating things from scratch, improvising and responding to the look that Russell wanted.”

Early in the film, Alice encounters a fan-favorite creature of the franchise — ferocious zombie dogs. Problems filming Doberman pinschers as zombie performers in the earlier films led the production to seek a new breed of canine. “We used Belgian Malinois,” explained Evan Jacobs. “They resembled bulky German shepherds, were incredibly obedient, but also very vicious-looking. It was a great foundation to create a different breed of zombie dog, and helped a lot with performances.”

The Tatopoulos team worked with animal handlers to acclimatize Malinois to spandex body suits that served as the foundations for prosthetic applications. “Once the dogs were used to the spandex,” Tatopoulos said, “we built up the rib cage and the hips using brush-cast latex elements and



Resident Evil: Extinction, the third movie taken from Capcom Entertainment’s shoot-‘em-up videogame, focused on the exploits of a genetically modified superhuman soldier Alice (Milla Jovovich) who encounters a zombie holocaust amid post-apocalyptic wastelands. Visual effects supervisor Evan Jacobs oversaw visual effects on desert locations and a studio shoot in Mexico City, while visual effects supervisor Dennis Berardi furnished digital

paint. They had learned on the previous films that dogs do not like applications close to the head; and so all we could do there was add a little coloring to the face to bring out some of the bone tones.” Mr. X digitally manipulated the dogs in post, adding a more dramatic meat-and-gristle texture and altering the animals’ faces with undead eyeballs and fangs.

effects at Mr. X in Toronto. Patrick Tatopoulos Studios artists Michael Mosher and Ralis Khan apply makeup to one of several hundred ‘desert undead’ zombies.

Escaping into the desert, Alice encounters a group of Raccoon City refugees who combat a murder of zombie crows. Tatopoulos Studios created crow puppets, using taxidermy pelts and rod-puppet mechanisms, to supplement live crows provided by the animal handlers. Mr. X sequence lead Daniel Mizuguchi generated wide shots of swarming flurries using live and digital birds. “We were going to shoot inserts and tile elements of live birds,” said Evan Jacobs. “The plan was to shoot a lock-off, bring in a crow, do another take, have him land in another position and then split-screen it together. Once we got on location, it was so hot the crows would only land in the shade. So instead, we pointed the camera at the sky and flew birds through, grabbing elements; of them flying. Mr. X used that footage as animation reference and as elements, so any time we saw a mass of birds, we had a live hero crow closer to camera.” Jacobs also shot crows against bluescreen in Mexico City for shots of birds attacking camera and pecking at the crow trainer’s face. Mr. X then added zombie eyeballs to birds for closeups.



Refugee survivors of the zombie plague use a truck-mounted flamethrower to fend off an attack by zombie crows. Special effects coordinator Darrel Pritchett supplied a diesel-fueled flamethrower for shooting in the Mexican desert location, where the production used four live crow performers and Tatopoulos Studios rod-puppet crows for closeups and attacking shots. The visual effects team shot elements of crows flying against the sky and elements of birds attacking camera during a bluescreen shoot. Mr. X used that footage as animation reference and as elements, combined with CG crows replicated en masse using digital flocking technology.

Shots of hundreds of crows in flight were animated using flocking technology developed by Mr. X senior technical supervisor Colin Withers. “We created point clouds in Maya particles,” stated Jacobs, “assigned crows to particles, extracted vector data and then aimed crows in the right direction. CG birds weren’t feathered in wide shots. Closer CG birds had feathers, but there were so many, it was more about the bulk than the individual crow.”

To repel crows, survivors wield a truck-mounted flamethrower, rigged by special effects coordinator Darrell Pritchett using a practical diesel-fueled device capable of producing a 100-foot jet of flame. Mr. X used practical pyro elements to suggest interaction of flames with CG crows and for shots of Alice interacting with flames, rescuing one of the refugees by bending fire with a telekinetic force field. “We mapped real fire textures onto 3D geometry,” said Jacobs. “It didn’t make a lot of sense to develop a huge synthetic fire system for a handful of shots. So instead we leveraged the amazing fire elements that we had on film, and manipulated them in the composite.”

Alice joins the survivors in a convoy of armored vehicles that sets out for the relative safety of Alaska, via a pit stop in the deserted ruins of Las Vegas. For actor interactions on the Vegas Strip,

production designer Eugenio Caballero built a 400-foot-long set on the Algodones Dunes, in Southern California, containing a 30-foot-tall section of the Paris Las Vegas Hotel & Casino façade and a portion of the Venetian. For wide shots of Vegas half-buried in sand, Jacobs brainstormed a cost-effective miniature approach with New Deal Studios miniature effects supervisor Matthew Gratzner. “We realized that if we shot a miniature on a huge stage it would cost a fortune,” commented Jacobs. “The scene was supposed to be in daylight, so we decided to shoot outside in natural sunlight, which looked better anyway and enabled us to shoot on the New Deal backlot. Matt and his team built everything in six weeks.”

New Deal designed miniatures based on Patrick Tatopoulos conceptual sketches, and then refined production previz to choreograph camera moves that followed a convoy of trucks through derelict buildings. Ruined casinos averaged between four- and five-feet tall, built in ‘HO’-scale. Modelmakers used a rapid-prototyping wax jet printer to mass-produce window mullions and building patterns, and dressed buildings onto an 80-by-45-foot platform, backed by bluescreen and covered in fine-grain sand.

Director of miniature photography Tim Angulo filmed motion control camera moves based on production footage. “We shot an aerial plate of a convoy of trucks driving on a dry lake in Mexico,” explained Jacobs. “We shot it from a helicopter on a windy day, and we only got a few takes. We tracked the plate and built it into our previz to try to reverse-engineer plates into our shots, but the producers preferred the previz to what we had shot from the helicopter and decided it was better not to compromise our shots to integrate the trucks. Mr. X ended up nudging in the live-action elements.” The sequence incorporated a move around a larger-scale foreground miniature of Lady Liberty, representing the wrecked frontage of the New York New York Hotel & Casino. Mr. X generated a digital Eiffel Tower for close shots of the Paris Hotel. “We designed the Vegas miniature around our budget, but the Eiffel Tower had a lot of very fine grid work and, at HO-scale, against bluescreen, all of the hair-sized girder work would have read as ‘noise.’ So Mr. X ended up rebuilding the tower digitally, without the finer grids.”



For shots of Alice and the refugees passing through the ruins of Las Vegas, the production filmed performers in Southern California desert locations and, for wide shots of casino buildings half-buried by sand dunes, used miniature effects created by New Deal Studios. Miniature effects supervisor Matthew Gratzner and his team built the miniature on the New Deal backlot and filmed it in natural sunlight, using motion control camera moves determined by previz and helicopter footage. Modelmaker Ray Moore prepares a section of the 1/87-scale Las Vegas Strip miniature.



Refugees employ a heavily armored truck to plow through throngs of desert undead lining the perimeter of a desert weather station, secret entryway to an underground zombie virus lab. For shooting in Mexico, the production built a full-scale vehicle. For scenes of the truck flipping onto its side and erupting in a fiery explosion, New Deal Studios constructed a 1/4-scale miniature. Modelmaker Jon Warren, who engineered the miniature sequence, uses radio control to drive the truck up a ramp, where several

hundred pounds of counterweight inside the tank cause the vehicle to roll.

The film's finale plays out at a desert weather station, secret entry to an underground Umbrella Corporation laboratory, surrounded by an army of undead. Eugenio Caballero constructed the weather station set at Laguna Salada dry lake in Mexico. Visual effects then furnished zombie hordes using a mixture of practical and digital characters. "The weather station was supposed to be surrounded by thousands of undead," said Jacobs. "We had 300 people, which did not even make one row surrounding the set. I shot lots of bluescreen texture photos of Patrick's desert undead, and they became the foundation for creating a digital undead army." Mr. X generated CG zombies as Massive artificial intelligence crowd simulations, with walk cycles designed to emulate practical zombie behavior.

Mr. X used Massive 'rag doll' simulations for shots of an armored tanker truck plowing through the undead, scattering them on the vehicle's cowcatcher. "We had big wide shots with CG zombies," remarked Jacobs. "We had tight shots where we had heads hitting the cowcatcher, blood flying and people crashing on the windshield. We approached that in a few different ways. We had the real truck on location and did some stunts where stuntmen rode on a platform, jumped onto the cowcatcher and bounced off the truck. We then took the cab, without the chassis, down to Mexico City, put it on a bluescreen stage and had stuntmen jump off mini-trampolines and on wires, throwing themselves into the cab. We then added moving backgrounds behind them."

Overwhelmed by zombies, the tanker skids and rolls, filmed using a 1/4-scale miniature engineered by modelmaker Jon Warren at New Deal Studios. "The ground at the location was not stable enough to shoot the tanker crash full-scale," stated Jacobs. "We were concerned about safety, so a miniature was the best way to go. The tricky thing about toppling a tanker is that they're designed not to topple. We had to rig a ramp the entire length of the miniature to get all the wheels up on one side. We put hundreds of pounds of counterweight on one side, inside the tank. Then, once we got it past its center point, it went over by itself."

New Deal used a winch to tug the miniature into shot at 15 miles per hour, steering with radio control, until the tanker's wheels hit a ramp and the tanker rolled. The production shot scenes inside the crashed tanker cab on a bluescreen stage in Mexico City, then cut wide to a miniature as the tanker explodes. New Deal aligned the miniature tanker crash to helicopter plates of the full-scale tanker positioned on its side in its final resting place beside the weather station fence. They then fitted the miniature tanker chassis with a thin aluminum cab and tank designed to rip apart with explosive detonations rigged by pyrotechnician Richard Stutsman. Mr. X digitally integrated miniature elements into desert plates and added Massive swarming zombies.

Inside the Umbrella laboratory, Alice discovers a chamber containing clones of herself suspended nude inside anti-gravity liquid bubbles. The concept was based on scientific research in diamagnetic levitation. "I showed Russell Mulcahy footage of experiments where scientists used electromagnets to make small organic objects float in midair," said Jacobs. "I suggested that the clone tanks could be like magnetic levitating balls of fluid, where clones grew inside. Russell thought that was a neat image. Patrick Tatopoulos drew a beautiful conceptual drawing and we filmed bluescreen elements of Milla breathing through a respirator in a water tank." Mr. X integrated bluescreen elements into

plates of Jovovich walking around an empty space on the clone tank set, and generated hovering liquid spheres using Maya fluids, with displacements and rippling effects.

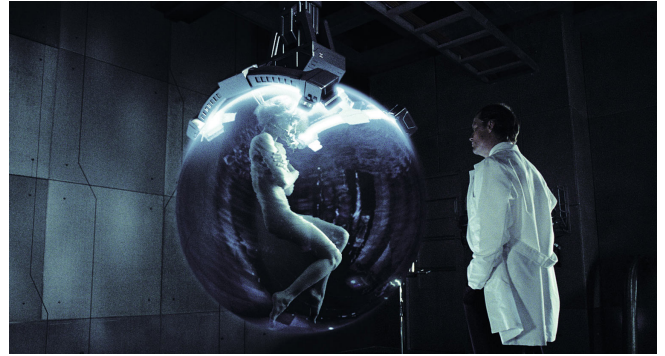
Alice meets her clones' creator, Dr. Isaacs (Iain Glen), who, infected with the zombie virus, has transformed into Tyrant, a powerful shape-shifting mutant. The Tyrant concept was inspired by creatures featured in more than a dozen versions of the game, translated into a modular full-body monster suit sculpted to fit Glen and stunt performer Brian Steele. "We wanted to take Tyrant through different stages as he transformed," said Patrick Tatopoulos, "but we didn't have the budget to build five or six suits, so we sculpted an upper torso, arm and face to fit a lifecast of Iain Glen, and then sculpted elements to be added as Tyrant transformed during his fight with Alice."

The creature team sculpted rigid appendages to simulate claws that spring from Tyrant's mutating inner core. "The idea was that the virus extrudes tendrils that become his claws," stated Tatopoulos.

"We sculpted the claws so that tendrils could be animated, with thousands of filaments growing together to become a hard spear, which he uses as a weapon. The main suit was made of latex; so, to reinforce his arm, we fabricated a rig on a cast of the actor's arm then built up the spear to about three feet long." Mr. X enhanced the suit with animated elements and created additional effects for a final showdown between Alice and Tyrant that takes place in a corridor equipped with a grid of flesh-slicing lasers — an environment reprised from the first Resident Evil film.

The sequence concluded 515 visual effects shots, completed by Mr. X during an intense eight-month postproduction period. "The Resident Evil movies are always made in post," concluded Jacobs, "and the vision is Paul's and Jeremy's. They know the games backward and forward, and always strive to give the fans a fun ride."

Resident Evil: Extinction photographs copyright © 2007 by Sony Screen Gems.



Rogue scientist Dr. Isaacs (Iain Glen) surveys one of many clones of Alice suspended in fluid-filled spheres inside his secret underground laboratory. The production based the visual concept for the floating spheres on real-world scientific research in diamagnetic levitation, where organic objects are suspended in electromagnetic fields. Mr. X generated the zero-gravity effect using bluescreen elements of Milla Jovovich filmed in a water tank, integrated the actress into a Maya fluid sphere with reflection and refraction effects, and then composited elements into the clone tank set.

Starstruck

ARTICLE BY JODY DUNCAN

No matter how extravagant the visual effects budget or how high the effects shot count, most directors insist that their movies are really ‘all about the story.’ It is, too often, a hollow claim, as evidenced by visual effects that are wielded like a cudgel, as if, through sheer force of visual assault, filmmakers can prevent a bludgeoned and sensory-overloaded audience from detecting a story as thin as Nicole Richie after a bout of stomach flu.

Starstruck

ARTICLE BY JODY DUNCAN



Stardust is a refreshing break from the norm. Directed by Matthew Vaughn — previously a director and producer of small independent films such as *Layer Cake* and *Lock, Stock and Two Smoking Barrels* — *Stardust* truly is all about the story. Based on Neil Gaiman’s graphic novel, and translated into a screenplay by Jane Goldman, *Stardust* recounts a collision of two worlds: the Victorian-era English village of Wall, named for the ancient stone wall surrounding it; and, on the other side of the enclosure, the magical realm of Stormhold, inhabited by witches and enchanted creatures.

Working with production visual effects producer Tim Field and production visual effects supervisor Peter Chiang, Vaughn opted for effects that would make the requisite story points as simply and elegantly as possible. The narrative-is-supreme philosophy, a modest budget and Vaughn’s limited visual effects experience dictated the approach, as did a desire to distinguish *Stardust* from other recent fantasy films such as the *Harry Potter* series and *The Chronicles of Narnia*. “We were all very conscious of the look and style of those films,” said Peter Chiang, “and Matthew was specific about not wanting this film to look like those. *Harry Potter* films are very sophisticated in their effects designs; but we were rooted to simpler dynamics. Matthew wasn’t resistant to our using sophisticated effects techniques, but he wanted them to be based on simple ideas. He wanted to present the magical elements of the story using common occurrences and images, like smoke and fire — things we’ve all seen.”

Awarded 330 shots, Double Negative was the main vendor on the show, with Chiang and visual effects producers Matt Plummer, Clare Tinsley and Andy Taylor overseeing the project. Chiang also brought in outside vendors — LipSync Post, Cinesite, Machine, *The Senate* Visual Effects, *Baseblack* Visual Effects and *Rushes* — to complete *Stardust*’s slate of more than 720 visual effects shots, integrated with live-action filmed on location in England and on stage at Pinewood Studios.

Stardust’s opening shot went to LipSync Post as part of its 138-shot assignment, overseen by visual effects producer Stefan Drury. “The camera sweeps across the night sky,” explained LipSync Post visual effects supervisor Sheila Wickens, “and then pulls back through a telescope and into an observatory interior where astronomers are working. We created everything in 3D — the sky, the moon, and the interior of the telescope, which we pull back through into the room. All we were

given was a live-action plate of the room interior, to which we added a domed retractable roof.” LipSync modeled its CG telescope based upon period reference, creating textures to suggest a burnished brass interior. The team also produced a 2D distortion effect as the camera pulled through the lens of the telescope, followed by a spectrum split created by the lens prism — homage to Pink Floyd’s Dark Side of the Moon album cover. The camera then pans around the room to a window, through which Big Ben was visible to establish London as the location. “We created a Big Ben matte painting out the window, with gas lamps and low lighting to suggest the Victorian period.”

High above the terrain, the camera moves from London to the village of Wall — the first of about a dozen ‘Google Earth’ type flyovers featured in the film. The purpose of the flyover shots was to acclimate viewers to the layout of Stormhold and its geographical relationship to Wall. “Matthew really wanted to explain the geography of Stormhold,” said Chiang, “because there are so many events going on at the same time in the movie, but at different locations. He wanted to show the relationship of Victorian England to Stormhold — where the wall was, where Stormhold Castle was in relation to the market town, et cetera. In order to do that, he designed several elaborate moves that took us from one location to another and showed where the various actions were taking place. The general approach we took to these shots was to shoot the front and end sections of each move; and then, to create the in-between glue that would join those two elements together, we generated these big establishing CG moves.”

Aerial photography and high-rez digital photography shot in Iceland and on Scotland’s Isle of Skye formed the basis of terrain maps used to create the bridging elements. “Matthew very much liked the vistas from those locations as the basis of the look of Stormhold,” observed Chiang. “A local mapping company gave us high-rez maps of an area on the Isle of Skye, and we used those terrain maps to build up our vistas and redesign camera moves to join up the opening live-action and the ending live-action.”

Shot as 4K tiles, the high-rez location photography covered several square miles, adding up to a tremendous amount of data. “Fortunately,” commented Double Negative digital effects supervisor Mattias Lindahl, “the quality of the photography was very good. Sometimes aerial photography isn’t really taken with an eye toward good-quality photography, mainly because it’s serving a different purpose. But these plates were very good. We did have to do some painting out of modern towers and power lines, of course. We set up a good pipeline for that, giving the compositors a lot of passes to do depth fogging, as well as height maps so you could really see the difference in atmosphere coming up from the earth to where the camera was. That was helpful in creating realistic results.” Double Negative also made use of a tool its research and development team had first developed for *Flyboys*, called Tecto, which enabled animators to work out layouts and camera moves in proxy, low-rez versions of the environments.

Reflecting set designs by production designer Gavin Bocquet, Double Negative dotted the Scotland and Iceland terrains with 3D or 2D Stormhold landmarks, such as the king's castle and a witches' lair that figures prominently in the story. To represent Wall, Bocquet had built a village set complete with several feet of its stone wall. Among the 78 shots awarded to *The Senate* — overseen by visual effects supervisor Simon Leech and visual effects producer Sarah Hemsley — were a number of wall extensions. "We worked on over 30 shots where we extended the wall on either the village side or the Stormhold side," Leech related. "We created wall elements in Photoshop, and then tracked them in Shake. We also had to grade the wall extensions to match the live-action, for both day and night shots. There were some shots that had mist in the distance, as well, and we had to phase the wall extensions into that mist to make the matte painting and the live-action blend together in those areas. That resulted in a seamless, never-ending wall."



Stardust concerns a lovesick lad, Tristan Thorne (Charlie Cox), who enters an enchanted realm to search for a fallen star that has taken the form of a beautiful woman, Yvaine (Claire Danes). Working with visual effects supervisor Peter Chiang, principal vendor Double Negative and a handful of other companies, director Matthew Vaughn opted for simple effects designs that would enhance the whimsical fantasy without overwhelming it. For the film's opening shot, LipSync Post created a camera pan across a night sky, followed by a pullback through the interior of a 3D telescope into a live-action observatory set topped with a CG domed ceiling.

The story begins in earnest when young Dunstan Thorne (Ben Barnes) tricks the old guard at the wall opening and runs through to find adventure on the other side. Dunstan soon finds himself in a colorful and fantastic market town, where gypsy-like vendors sell exotic wares and exhibit oddities such as a miniature two-headed elephant and a glass jar of moving eyes. "The eyeballs were originally designed as a practical gag that special effects built as a remote control rig," explained Peter Chiang. "After it was shot, we came up with the idea to have some fun with the eyeballs — which was deemed too complicated for the mechanical rig — and so we decided to do them CG."

Baseblack created the eyeballs in the jar, giving them a cartoonish look, and also animated the miniature two-headed elephant in the cage. "The cage shot went through several designs," recalled Chiang. "The first was a strange half-gorilla mechanical creature that was going to be stop-motion animated. The second was a man in a strange creature suit, shot with a scaled motion control move tracked off the plate. Matthew opted in the end for something more appealing, and so I presented him with this 'push-me-pull-you' elephant — my homage to Ray Harryhausen's tiny horse, 'eohippus,' from *The Valley of Gwangi*."

The magical town also features a seductive young woman, Una (Kate Magowan), who is enslaved by the witch Ditchwater Sal (Melanie Hill), attached to her cart via a magical chain. Later in the film, we see Sal transform Una into a bird sitting on a perch. "Una's transformation is an example of the simple effects designs Matthew preferred," Chiang commented. "He wanted the transformation to be done in a puff of blue smoke — since audiences could easily relate to smoke — and then we assigned the digital tools needed to create that look."

Starting with two plates — one with Kate Magowan in frame, the second with the bird in frame — Double Negative used particle simulations to generate the fluid blue smoke bridging them. “The smoke forms a human shape around Una,” explained Mattias Lindahl, “then forms a bird shape. The bird in the plate comes out of that smoky bird shape.”

Una lures Dunstan into the cart, and what transpires there is confirmed when, nine months later, a baby boy named Tristan is delivered in a basket to Dunstan’s home in Wall. The narrative moves ahead many years to find Tristan (Charlie Cox) as a young man, desperately in love with the vapid but beautiful Victoria (Sienna Miller). Though Victoria is supremely disinterested in the goodhearted, but bumbling youth, she agrees to join him in a picnic under the starry sky.

In one of the film’s flyover shots, the camera pulls away from the picnic scene and travels to Stormhold Castle, where the aged king (Peter O’Toole) lies dying as the surviving four of his seven sons angle to be named heir. “We did a big camera move off of the picnic scene to start our flyover shot,” said Peter Chiang. “For the other end of the shot, where we wound up in the king’s bedroom, we did a huge descender rig move inside the set, dropping down onto Peter O’Toole on the bed.” As with the other flyovers, Double Negative generated all of the in-between terrain imagery from aerial photography and high-rez stills, adding in necessary CG elements such as the castle exterior.

The three dead princes of Stormhold — soon joined in the afterlife by their brothers as each suffers a grisly death — inhabit the king’s bedroom and other scenes throughout the movie, offering commentary on the worldly events. Prosthetics designer Nik Williams created makeups that suggested the mode of demise for each of the ghost actors. Williams fitted Secundus (Rupert Everett) with prosthetics designed to appear as if his face had been smashed in, his hair flown out permanently to the side, indicating his death in a fall. Another brother, having frozen to death, was made up with icy particles on his face, while still another, killed in a fire, had a burn makeup applied.

Vaughn shot the ghost performers, in makeup, during a separate 10-day greenscreen shoot. As part of their 67-shot assignment, Cinesite and visual effects supervisor Stuart Partridge composited the performances into scenes, processing the greenscreen elements to achieve a ghostly look. “The ghosts went through a long development phase,” Peter Chiang noted. “We thought, early on, that it would involve a lot of 3D, with the demise of each ghost being reprised every now and then. The guy who was burned, for example, would suddenly burst into flames; or, the frozen guy would start talking and moving very slowly and then freeze. But in the end, Matthew wanted to let the comedians’ performances shine through, without all of this



In a prologue sequence – set years before the main narrative – Dunstan Thorne, Tristan’s soon-to-be father, flaunts local tradition and law when he breaches his village’s stone wall to visit the magical realm of Stormhold on the other side. Dunstan finds himself in an exotic marketplace that features, among other oddities, a miniature, two-headed elephant in a cage. Baseblack

distraction, so we wound up having Cinesite do fairly typical ethereal ghosts.”

The final ghost effect has the characters emanating a white glow, with areas of their bodies becoming more or less transparent as they move. “We designed the look using some Shake tools,” observed Stuart Partridge, “but also some proprietary Cinesite nodes that have been written for Shake. We created a luminance and transparency node, which added an ethereal glow to the ghosts. This script also applied a desaturated look, and keyed in different parts of the background through the ghosts, to give them a transparent, ethereal feeling.”

After Secondus falls to his death, pushed through his father’s bedroom window by an ambitious brother, the King of Stormhold rises from his deathbed to toss a ruby necklace — turned from blood red to a clear white — into the sky, proclaiming that whichever heir finds the necklace and restores the ruby to its proper hue will be the new King of Stormhold. As the necklace rises into the night sky, it collides with a star, knocking it out of the heavens and causing it to fall to earth. When Victoria admires the falling star, as viewed from the picnic spot, Tristan promises to travel into the magical realm and retrieve it, in exchange for her hand in marriage.

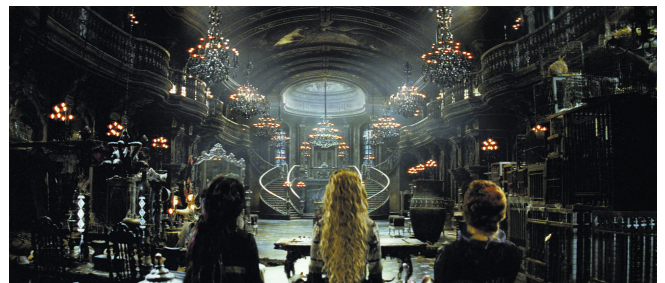
The falling star sequence, played primarily from the star’s POV, was one of the most effects-laden of the film, involving a CG star in CG space, live-action photography, greenscreen elements, helicopter plates of a wood in England, and a miniature built by Leigh Took of Mattes and Miniatures. “A combination of many different elements went into that one shot,” said Peter Chiang. “We’re point-of-view flying from 2,000 feet up in the air, gliding over a night vista of Stormhold, which is all CG. We then see the CG star race away from us.” One of Matthew Vaughn’s directives was that the star should not look like a ball of fire, but rather a confluence of solar flares done in a very cool color palette of blues and purples.

For the star’s impact, Chiang took inspiration from the asteroid impact sequence realized by Hoyt Yeatman for *Armageddon*. “I wanted a similar type of

Visual Effects animated the CG creature and nestled it into live-action shot on a market town set. The story fast-forwards to pick up Tristan – conceived in the marketplace and delivered to his father’s doorstep in a basket – as a young man, besotted with the most beautiful girl in the village.



In Stormhold, three ancient witches plot to regain their youth and beauty by catching the fallen star and eating her heart. To realize exteriors of the witches’ lair, situated in a volcanic cavern, Double Negative artists projected digital matte paintings onto computer generated geometry, using textures photographed on Scotland’s rugged Isle of Skye to simulate the rocky lair walls. Double Negative employed its proprietary water- and oceangenerating engine to create the surrounding water, incorporating practical elements for additional depth and atmospherics.



Vaughn filmed lair interiors on a set designed by production designer Gavin Bocquet and constructed on stage at Pinewood Studios. LipSync used matte painted elements to extend the witches’ lair set depth-wise and create an ornate ceiling. For an introductory lair shot, in which chandeliers switch on in sequence as the camera moves through the interior, LipSync created transitions to combine seventeen separately-filmed plates into one seamless shot.

thing,” stated Chiang, “a pulse of debris and earth emanating from the center of the impact zone.” The initial impact was a practical explosion effect rigged by Leigh Took and shot in a field. “We then glide down into a burnt trail made by the fallen star in the forest, with trees bent over on their sides and tree stumps charred — and that was the miniature element, with flames on it. Then we come up to the upper ridge of the crater — which is CG, but is based on the 50-foot section of crater interior Gavin Bocquet created on stage at Pinewood. The camera rises over the lip of that crater, in CG, and you see a bright pulsing light. We track into that light, the CG melds with the live-action set, and then the glow dies down and we find Claire Danes in the center of the crater.” Danes portrays Yvaine, the fallen star who, in the fantastical physics of *Stormhold*, takes the form of a beautiful young woman.

Back at Wall — after failing to get past the wall guard so that he might enter the magical world and find the fallen star — Tristan learns from his father (Nathaniel Parker) the unusual circumstances of his conception. Dunstan presents Tristan with the basket in which he arrived as a baby, together with a letter from his mother and a ‘Babylon candle,’ a magical mode of transportation requiring a person only to think of his desired destination. Tristan’s thoughts send him on a quick flight that ends with his careening headlong into Yvaine in the crater.

LipSync executed the shot leading up to the *Babylon* candle flight, in which Tristan and Dunstan are in the attic and Tristan lights up the candle. LipSync combined that plate with a clean plate that featured a practical lighting effect to create a sudden burst of light. Double Negative picked up the sequence from there, producing shots of Tristan in flight. “Peter wanted the *Babylon* candle effect to look like a flame in zero gravity,” observed Mattias Lindahl. “When Tristan is actually flying through the air, he is essentially a flare effect, with this weird zero-gravity flame around him.”

Initially annoyed at being knocked out of the sky then struck by a catapulted human, Yvaine eventually warms to Tristan and to her earth-bound experience, her happiness revealing itself in a subtle glow that emanates from within. Peter Chiang charged LipSync Post with all 70 of the Yvaine shimmer shots. “They had considered a 3D approach early on,” remarked Glen Pratt, LipSync’s compositing supervisor, “but the budget didn’t really allow for that. So our brief was to come up with a creative 2D solution to the shimmer shots that could be applied procedurally. Initially, Matthew was keen for the effect to be glittery and sparkly; but as time went on, he thought that might be too busy an effect. Our head of film technology, David Lloyd, set up a pipeline that allowed us to output about 150 versions of the shimmers quickly. Matthew and Peter then settled on the final look, which was one of the most subtle of the effects, without any glittery particles. It was just a gentle glow surrounding her and coming from her.” LipSync used optical flow data from the live-action plates to create the shimmer effects. “The optical flow information gave us vectors for her movement in the plate, which were used in combination with luminance keys to pick up her highlights. We also created animated noise and used a proprietary plug-in to create beams coming out from her, based on her movement and emotional state.”

Tristan chains Yvaine to him and sets out for Wall, where he intends to present her to Victoria and thus win his true love's hand. In another part of Stormhold, the fallen star has caught the attention of three witch sisters, aged crones who have waited 400 years for a star to fall, so that they may cut out her heart and consume it, restoring their youth and beauty. Nik Williams applied extreme old-age prosthetics to Michelle Pfeiffer, as the witch Lamia, and her sisters. LipSync executed the transformation of Lamia from old to young when she eats the last bit of heart remaining from the last fallen star. "We created the magical transformation from a haggard old witch to the beautiful young one," remarked Sheila Wickens. "We received several motion control plates: a clean background plate, a plate with the two sisters, one rotation of Lamia with all of the prosthetic makeup and scraggly hair on her, and then one rotation of her as she looks at the end."

A final motion control pass was on a special blue-painted head with long flowing strands of hair that could be pulled through to the inside, creating a bald look. The footage would then be run in reverse to suggest strands of hair growing out. "We always felt that the hair was going to be a problem," said Peter Chiang, "because you always see hair jumping around during these kinds of transition shots. So we wanted the hair to be a practical motion control element, rather than attempting to do a dissolve or a series of morphs. We shot this head with long strands of hair, running the motion control rig and pulling in all of the hair in one pass — so we were never morphing hair from one motion control pass to another. We had the old Michelle Pfeiffer in a bald wig with strands of hair at the beginning, and the young Michelle Pfeiffer with this lovely flowing hair at the end — but the bridging hair element was actually this separate motion control pass where we pulled in hair through holes in the blue skull, then ran it in reverse to make it appear as if that hair was growing out."

Much of the transformation is played from behind Lamia, with her front side reflected only briefly in a tall mirror. "You see her face transforming in her reflection as the camera pans around her," observed Wickens, "but it is mostly seen from the back of the head. That was all done in Shake by morphing between the plates. There was an awful lot of tracking and matching of plates; and it was one of the shots that took us the most time to finish. The trickiest part was the hair, and we got around that by hiding some of the joins with the shimmer effect and flares coming out."



To trap Yvaine, the witch Lamia (Michelle Pfeiffer) uses her magical powers to create an inviting inn in an empty field. To produce reference for the look of the inn emerging from flames, Double Negative built a foamcore structure, set it alight and filmed it, and then ran the film in reverse. Double Negative then re-created the look digitally, building inn geometry that grew out of synthetic fire and smoke.

LipSync also matte painted elements to extend the interior witches' lair set used for the live-action. "We created the ceiling as a matte painting and extended the set out quite a bit," stated Wickens. "There is an initial shot where we introduce the lair, and all of the lights switch on. That shot was made up of 17 plates — each only about ten frames long — with different lights switched on. We had to make that look like one seamless magical effect of the lair being lit up." Lair exteriors were all created by Double Negative.

Now young and beautiful again, Lamia sets out to find the fallen star, transforming a farm boy into a goat to help pull her small carriage. Double Negative executed all of the magic effects for Lamia and her sisters, each of whom emits a different colored flame from her fingertips. "The magic effects are flame and smoke," noted Mattias Lindahl. "Lamia's flames are always green, while the others are red and blue. We used a fluid sim to create the smoke, and a particle-based system for the flames. Technical director Pawel Grochola studied how flames would move, and set up ribbons to emulate them — soft-body surfaces with fire textures on them that deformed and moved to create a flame look. That proved to be quite successful."

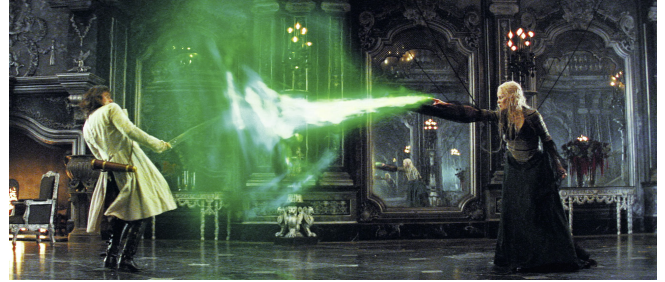
Meanwhile, in another part of Stormhold, Yvaine manages to escape Tristan — who has gone in search of food — when a white unicorn comes to her aid. Production had first attempted to create the unicorn by mounting a prosthetic horn to a horse's head, but the approach was not successful. Machine, as part of its 43-shot assignment, tracked a CG horn to the head of a large white horse to create the mythical creature. "We did a lot of 3D tracking on the horse's head," said Machine visual effects supervisor Steve Street. "That was just a lot of old-fashioned matchmoving. One shot moves in quite close to the horse's head, so it had to be a perfect replication."

"First," added visual effects supervisor John Lockwood, "we had to remove the practical horn and reconstruct the parts of the horse's head and backgrounds that had been covered by it. Then we did our matchmove, and tracked in the CG horn. There was only one shot where they hadn't used the practical horn, so we had to do that for all ten of our unicorn shots, except one." Machine also enhanced weather effects for shots of Yvaine riding the unicorn in a storm, adding digital atmospherics.



Having escaped Lamia's trap, Tristan and Yvaine are hosted by Captain Shakespeare (Robert De Niro) in his lightning-harvesting ship. For close- to mid-range shots, production built the hull of the flying ship at Pinewood, and surrounded it with a 360-degree floating greenscreen. In postproduction, Double Negative extended the set digitally and composited aerial backgrounds into the greenscreen areas. Wide shots of the ship in flight required Double Negative to model a CG vessel from art department blueprints and survey data, with high-resolution photographs of the set providing textures.

Alerted by her sisters that Yvaine is nearby, Lamia uses her fiery green magic to create a welcoming inn in an empty field, her plan to offer the soaked girl shelter, and then cut out her heart. The creation of the inn was typical of the film's simple effects approach. "There were thousands of ways we could have gone with that effect," said Peter Chiang. "What we did was build a prototype foamcore house that was about fifteen feet wide, set it alight and film it. Matthew wanted us to re-create the look of that footage, run in reverse, which would look as if the house was being formed in these flames, instead of being destroyed in them. From there, we got into building the actual geometry and creating the look with more sophisticated effects. Matthew wanted the flames to do specific things — like loop around and fly in through the window — so we had to generate them through a combination of fluid simulations and mapped flame elements."



Lamia and Tristan face off inside the witches' lair. Double Negative executed the magic effects for Lamia and her sisters, each of whom fires a different colored flame and smoke from her fingertips. Double Negative used a fluid simulation to create the smoke, and a particle-based system for the flames, projecting fire textures onto ribbons of soft-body surfaces that deformed to emulate the movement of practical flames. Prosthetics designer Nik Williams designed and executed a series of makeups for Michelle Pfeiffer to simulate various stages of aging.

Tristan finds Yvaine at the inn just as Lamia is about to kill her, and employs his *Babylon* candle to make their escape. But with Tristan wishing on the candle to go home to Wall, and Yvaine thinking of her home in the heavens, the pair land somewhere in between, stranded on stormy clouds, with strikes of lightning surrounding them. Double Negative pushed the limits of its voxel renderer, DNB, to generate the clouds for the scene, constructed by a cloud team under the direction of 3D technical supervisor Gavin Graham. Traveling shots covering vast distances also required the team to push its tools to create a great volume and diversity of cloud formations. Particle work carried out by dynamics technical director Nicholas New allowed the team to render clouds on different channels, so that compositors could grade them according to the requirements of each shot, be it a daytime or night, overcast or bright. Proprietary tools such as dnCloud and gtoMunch provided artists with a means to preview the clouds at low resolutions inside Maya, so they could work on layouts in real time.

Captain Shakespeare (Robert De Niro) and his roughneck crew of lightning-harvesters pick up the cloud-stranded couple and bring them aboard their flying ship, threatening them with all manner of harm, including rape and murder. Gavin Bocquet designed the ship to reflect the Victorian era — complete with a massive balloon that keeps the ship aloft — and built the hull on stage at Pinewood for close- to mid-range shots. Production surrounded the set with a 360-degree floating greenscreen, which provided director of photography Ben Davis the flexibility to shoot live-action from any angle.

In postproduction, Double Negative extended the ship set digitally and composited aerial backgrounds into the greenscreen matte area. Double Negative also created a CG model for wide shots of the vessel flying through stormy skies. 3D supervisor Rick Leary began modeling the ship early in the shoot, using art department blueprints. Once Gavin Bocquet's team had built the set, Double Negative made use of a surveying tool, Total Stations, to complete the CG ship model. "You point this survey tool at an object," explained Mattias Lindahl, "and it triangulates points. Normally, you see these surveying tools out on building sites, but we developed tools so we could use it to get the survey data into Maya."

Leary designed dynamics to make the lightning nets on the CG vessel open and close procedurally.

Modeler Jordan Kirk modeled the balloon and mast flags, both of which were rigged for animation by Gia Sadhwani. Texture artist Guy Williams shot very high-resolution photographs of the set, from bow to stern, to provide the basis of textures for the CG ship. Modeler James Guy stitched the texture photos together in Double Negative's proprietary software, STIG, and used other in-house tools to project and bake the textures onto the CG model.

Many shots had the camera starting on live-action filmed on the greenscreen stage, then pulling back, requiring an invisible transition to the CG ship, executed by Double Negative 2D supervisor Paul Riddle and his compositing team. "We'd start off with the greenscreen footage and a big swooping camera move," explained Mattias Lindahl, "and then we'd do the CG takeover, going from the real ship to our CG ship. We also put in CG characters to make it look like there were people on the ship."

Captain Shakespeare's ruthless demeanor soon proves to be a façade for a man well in touch with his softer side. The captain takes Tristan and Yvaine under his wing, teaching the former much about how to be a man — and even giving him a better haircut. The captain then helps the pair return to Tristan's home, making a rather inept crash-landing of the ship in a lake nearby. The sequence combined live-action on the ship set with Double Negative's CG ship and helicopter footage of a lake in Scotland.

LipSync composited the set with ground-level lake backgrounds for shots of Tristan and Yvaine leaving the docked ship and heading off, on foot, to Wall. "They'd shot backgrounds for the ship docked on the lake in Scotland, on a miserably dark day," recalled Sheila Wickens. "So we had to make it look nice and bright and sunny. Those shots took quite a bit of work, because the ship was a set shot in a studio and the exterior was a dull day. There was extensive grading to get that to work."

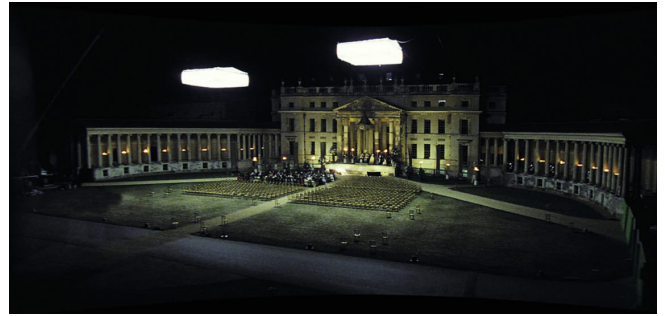


Tristan professes his love for Yvaine, witnessed by his mother, Una (Kate Magowan), and the seven ghost princes of Stormhold. Nik Williams created makeups to suggest the mode of demise for each of the princes, who are featured as comic relief throughout the film. Vaughn shot the performers in makeup during a 10-day greenscreen shoot. Cinesite artists composited the ghosts into scenes, processing the greenscreen elements using Shake and proprietary tools to create a glowing, ethereal look. A custom script desaturated the characters and keyed in different parts of the background to suggest transparency.

On their way to Wall, the pair hitch a ride with Ditchwater Sal — who transforms Tristan into a mouse. Gray and black smoke attended Sal's transformation magic, the design of which was developed at Double Negative under the supervision of Gavin Graham. "Matthew always wanted Sal's magic to be dirty and grungy," related Peter Chiang, "which is why it takes the form of black smoke, rather than the beautiful colored flame of Lamia and her sisters. Tristan turns into a mouse in a puff of black smoke; and then, later, when she transforms him back to a man, Tristan reappears from out of a black cloud of smoke." With fluid simulations notoriously difficult to art-direct, 3D artist Bjorn Henriksson used a variety of Double Negative's in-house tools to turn animated geometry into a target-driven fluid simulation, allowing for a more sophisticated effect than what could be achieved with an out-of-the-box simulation.

Double Negative integrated the magical smoke elements with a simple, in-camera transformation. "Where, normally, you would get into morphing and all of that for a transformation from one creature to another," said Chiang, "Matthew played this transformation from the point of view of the subject. We just put an 8mm lens on a camera, and shot a jib-down — as if Tristan's POV is suddenly going from a six-foot height to the ground-level of a mouse — and then we added our CG black smoke along the edges."

When they arrive at the Stormhold market town near Wall, Tristan and Yvaine spend some time alone at an inn, where they profess their love. The scene then cuts to the two of them lying together on a bed. Vaughn had filmed the scene with Charlie Cox bare-chested — but a combination of aesthetic and ratings board concerns led to the postproduction decision that Tristan should be wearing his shirt in the scene. At Pinewood, Peter Chiang shot bluescreen clothing elements for *The Senate* to track into the original three shots. "Charlie Cox was filmed in his shirt," recalled Simon Leech, "lying on a



When Tristan is proven to be the heir to the Stormhold throne, he is crowned in a lavish ceremony. The coronation scene was shot at a historic school building outside London. Double Negative extended the location setting and transformed a small crowd of 50 on-set extras into a throng of thousands by duplicating the extras in live-action areas and adding digital crowds to the CG set extensions.



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platform made to look like the bed in the scene. Markers indicated where Claire Danes' head and body were positioned. To give us the elements we needed, the actor had to re-create what he had done in the scene originally, which was quite a difficult thing to ask of him. Of course, we had the scene there on the monitor, so he could see what he needed to re-create; and, fortunately, it was quite a short scene."

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To create the new scene, *The Senate* integrated the bluescreen footage into a shot of Claire Danes in the bed alone — originally shot for a later scene, when Tristan has left her to tell Victoria of his change of heart. Another two shots had Tristan's arm — bare originally, but now in a shirt — coming into frame, across the bed, as the camera panned with him. "We had to put a new shirt on his arm for that shot," said Leech. "He was shot again, against blue, copying the camera move on the arm, and acting out the scene as before. We rotoed out the actual shirt, so we had the shirtsleeve element on its own, and then we put that back over the original arm in the scene. Of course, he hadn't been able to exactly re-create the movement and timing of the original arm — it would have been impossible — and so we had to warp the new element a bit and re-time it to move exactly with him in the original plate."

At the entrance to Wall, Lamia captures Yvaine and transports her to her lair, along with Una, who has escaped Ditchwater Sal. Tristan and Septimus (Mark Strong) — the last surviving Stormhold prince, who is seeking the ruby necklace Yvaine found and placed around her neck — race after them, engaging the three witches in an extended battle at the lair. *The Senate* provided flame effects for a contest between Septimus and Empusa (Sarah Alexander) who — like her sister — shoots flame and smoke from her fingertips. *The Senate* worked with 4K flame and smoke elements provided by the production to create the effects shots. "Working closely with Peter Chiang," observed Leech, "we decided what sort of flame and smoke movement was needed for each scene — how the flames and smoke would wrap around Septimus or move with him — and then our animators reviewed all of the element material and chose specific sections. After choosing a section of flame element, we added it to the scene, doing whatever warping or re-timing was necessary. There was a lot of back and forth between Peter and *The Senate* to make sure he was getting the animation he wanted. Sometimes we had to mix through from one flame to another in the course of a shot. There also was a lot of reactive lighting added to his jacket to make it look as if the flames were actually on his back."

Lamia kills Septimus by dropping a voodoo doll in a fountain, causing the prince to rise up in the air — as if suspended in water — and drown. Machine realized the drowning effect, integrating footage of Mark Strong shot in a water tank into the lair environment. "We had to take the water tank element and make it look as if the character was inside the witches' lair," explained John Lockwood. "Of course, the element had all the problems you get with people in water — the hair had air bubbles in it, and he was breathing out slightly, so there were air bubbles moving across his face. We had to remove all of those bubbles, as well as safety rigs used to shoot the water tank material. Another problem was that the color, because it was in water, was nonexistent — pretty much just a

flat cyan. A lot of matte and paint work, and a lot of color correction, was needed to bring the color back into his face and make it look as if he was part of the background plate.”

Machine also did a composite for a later shot in the lair battle, when Tristan releases caged wolves and other creatures to attack their witch captors. “Obviously,” said Steve Street, “they couldn’t mix actors and wolves. So the wolves were shot separately, greenscreen, and we comped them over the live-action background. The actors were shot greenscreen, as well, and comped over the same background.”

Baseblack Visual Effects helped to create shots of the dead Septimus engaging Tristan in a sword fight during the final battle, orchestrated by Lamia’s manipulation of the voodoo doll. “Every time Lamia moves something on the voodoo doll,” noted Peter Chiang, “Septimus’ body makes the same move. That involved a lot of complicated rigs to allow Mark Strong to relax and play dead, but at the same time move around and do this sword fight. There was a rig holding his body up, as his legs dragged along the floor and his arms were swinging this way and that, waving the sword around. *Baseblack* had to remove all of those rigs. They also did a lot of re-timing to make that work.”

During the fight with Lamia, Tristan unleashes lightning bottled in a tube — a gift from Captain Shakespeare. *The Senate* created the shots, expanding on animated lightning effects it had created for an earlier scene in which Captain Shakespeare sells his harvested lightning to a dealer. “Tristan aims this lightning at Lamia,” said Simon Leech, “which makes her sail back in the air. They did that using a rig, which we had to remove from the shots. A lot of work was done in the comp to make the lightning sit in where the interactive light was flickering. We also had to put in lightning reflections on the floor.”

Happy in her love for Tristan, Yvaine does what stars do best: she shines, the light energy building to such an intensity, it destroys the witches and their lair. *LipSync Post*, charged with the more subtle Yvaine glows, generated her ultimate shimmer effect, as well. “That was one of the last shots we did,” Sheila Wickens said, “because Matthew was concerned that the ending of the film be very dramatic. He wanted the audience to feel the intense brightness of the star coming out of the screen, almost blinding them. It had to be many times greater and more intense a light than we’d seen so far. So for those particular shots, in addition to the other methods we had used for the glows, we added 3D particles to create a dome of light and energy around her.” *LipSync* senior compositor Tom Collier assembled all of the elements, along with lens flares, distortion and camera shake to add intensity and drama to the shots. Effects company *Rushes* came in at the end to create a shot of Lamia exploding in the starburst, and also created set extensions for other scenes in the film.

With the destruction of the lair, the Stormhold ghosts ascend to their final resting place in a shot generated by *Cinesite*. “We cut to a closeup of the ghosts, as they rise up,” stated Stuart Partridge. “The actors were lifted on wires, shot against greenscreen. Then we go wide to see the ghosts transform into glowing, mid-state particles. They then continue to rise up, each one evaporating into a ball of celestial light, which becomes wispy and fairy-like as they zoom upward. We used CG particle trails, smoke and interactive CG lighting to create this effect. We also had to do a lot of heavy cleanup on the greenscreen wire setup, because there were wires in front of people’s faces and so forth.”

Having saved Yvaine, Tristan picks up the fallen ruby necklace and the clear stone reverts to ruby red — affirming him to be the rightful heir to the Stormhold throne. A coronation scene was shot at a historic school outside London. Double Negative extended the location, and replicated the 50-odd extras there to create appropriate throngs. “We added CG crowds to the CG set extension areas,” noted Mattias Lindahl, “and duplicated the real crowd, which had been shot in various parts of the set, for other areas.”

Whereas effects artists are often commanded to make it big, Matthew Vaughn directed the effects artists on *Stardust* to keep it simple. “Matthew came at it with a fantastic, almost innocent perspective on visual effects, which was quite refreshing,” Peter Chiang concluded. “He would be the first to admit that he was on a learning curve when it came to the technology; but once he began to understand it better, he really embraced what it could do for his film, and he allowed the tool set to deliver his vision.”

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Bots & Bayhem

Article By Jody Duncan

Shortly into *Transformers* — director Michael Bay's production inspired by the popular Hasbro toy line — teenage misfit Sam Witwicky (Shia LaBeouf)

image

watches from a bedroom window as his 1974 Camaro roars out of his driveway, presumably the target of a car thief. In pursuit on his mother's pink bicycle, Sam catches up to the Camaro in a nearby junkyard where, incredibly, the driverless vehicle transforms into a 20-foot-tall robot, later identified as Bumblebee, one of a band of displaced robotic denizens from an obsolete alien civilization.

This transformation from car to robot was the fruition of two years' work at Industrial Light & Magic where, under the supervision of visual effects supervisor Scott Farrar, a team of creature developers, modelers, animators and technical directors created 14 computer animated hero robot characters, the likes of which had never graced a movie screen. "When we first started on this project," Farrar remarked, "we researched similar types of characters in other movies, and we were surprised to discover that nobody had ever really done a film about giant, realistic looking robots. There was a robot in *Short Circuit*, but that was a cute little mechanical thing. C3PO was a cool robot, but it was an actor inside a suit. The robots in *I, Robot* were a totally different design idea. This project was completely different from anything that's ever been tried before. The goal was to make our characters look photoreal, and to act, speak and move in a cool, athletic fashion."

From the beginning, enthusiasm for the *Transformers* project was high at ILM, as twenty-something animators and technical directors who had grown up with '80s-era *Transformers* toys, animated television series and movies saw a chance to re-energize childhood icons for the big screen. "As soon as the artists started hearing rumors that Michael Bay was going to do this show," recalled ILM visual effects producer Shari Hanson, "Scott and I were besieged by the fans in our midst. It seemed like every artist at ILM wanted to be a part of *Transformers*. They begged to be on the project. They promised to work for free — which, of course, didn't quite pan out. Not only did the *Transformers* property have a lot of big fans here, so did Michael Bay, who is known for the kind of striking, memorable images visual effects artists dream of creating."

As scripted by Roberto Orci and Alex Kurtzman, *Transformers* is, at its core, a coming-of-age story about a boy, his first car, his first girl — and his first robot. Set against that human tale is a war between members of a destroyed technological world. On one side are the Decepticons, whose intention is to usurp mankind's dominance of planet earth. Dedicated to protecting humankind are the Autobots, led by Optimus Prime. Members of both factions hide within human society, able to take the form of automobiles, trucks, jets and other mechanical devices.

Michael Bay was just finishing his 2005 film, *The Island*, when he began visualizing *Transformers* with a small team of previz artists, led by Steven Yamamoto. Simultaneous to the previz effort, a team of concept artists worked alongside the director at Bay Films, designing the Decepticons and

the Autobots in all their various forms. Those designs were then turned over to ILM, where visual effects art director Alex Jaeger translated the fantastic renderings into characters that would read credibly in three dimensions.

Designs continued to evolve as principal photography commenced in the desert of New Mexico, at the Hoover Dam in Nevada, in downtown Los Angeles, and on stages at Playa Vista. Farrar and his visual effects crews sprinted to keep up with Michael Bay's fast-paced shooting style, which often yielded 40 to 50 multiple-camera setups a day. "We would have five or six cameras running," stated Farrar, "two of them on dollies, one on a Technocrane, one a Steadicam, and a couple on tripods, with most of those cameras moving all the time. It was just wild out there — but it made for a very loose, free style on the set, and it gave the movie a very exciting look."

The wild camera moves and fast setups made motion control a nonviable option. Instead, on-set matchmover Duncan Blackman and production coordinator Ryan Wiederkehr tracked and measured sets so that ILM's digimatte team could re-create environments digitally. ILM's on-set crew also shot high dynamic range photographs of every setup so that lighting environments could be matched exactly. "We used a tilemaker for that," explained associate visual effects supervisor Russell Earl, "which we could set up on a tripod. That allowed us to shoot nodally-perfect 360-degree spheres, which we then stitched together at very high resolution. If we didn't have time to set up our tripod, Duncan Blackman would shoot handheld spheres. With these high-rez photos, the digital matte department could re-create very accurate and complete reflections and lighting."

Chrome spheres were used for more generic lighting reference, as were plastic baseball caps painted to match the car and robot colors. The latter were not only highly portable and color appropriate, they featured — in small scale — the curves, sharp edges, flat planes and shiny reflective qualities that would characterize the robots and their vehicular forms.

The on-set crew was also responsible for providing eye-line guidance for the actors as they interacted with robots of various heights moving through scenes. Initially, Michael Bay had considered employing full-scale robot heads on set; but past experience had taught Scott Farrar that such full-size props are cumbersome. While a few full-size, lightweight heads were built, the crew most often used simple cardboard cutouts or extendable window-washer poles to mark the height of a given Transformer robot in frame. "It was a real challenge," said Earl, "because we were shooting plates for 30- and 40-foot-tall robots that didn't exist. Even though we had these reference poles, everybody really had to use their imagination on the set. Michael is great at composing big, dynamic shots; but those types of shots made it difficult for us to imagine where the robot would be and what he would be doing. All during the shoot, we were thinking, 'Oh, boy, I hope this works,' just because there were so many big camera moves and so much action going on."

Adding to the mayhem on the set were special effects gags orchestrated by special effects supervisor John Frazier and his crew. The special effects assignment, among the biggest of Frazier's long career, involved engineering heavy mechanical gags to suggest the impact of fighting robots on location and stage sets, and large-scale explosions



numbering in the hundreds. “The first thing Michael Bay said when we started this,” recalled Farrar, “was: ‘I want to do things real and dirty. Can we blow things up and have real dust and debris on set, with lots of lights and flaring and bling?’ And I said, ‘Absolutely — let’s do that.’ Not every filmmaker will take the time to do that on set, but it adds so much reality to the shots. Of course, having all of that stuff in the plates made things more difficult for our compositors and our roto/paint people; but that’s just how movies are made now, and they all embraced it.”

The Decepticon Skorponok bursts from the sands of Qatar to launch an attack on a special operations military unit in director Michael Bay’s Transformers, a blockbuster summer offering inspired by the popular 1980s Transformers toy line. According to Transformers mythology, good-guy Autobots and bad-guy Decepticons, all denizens of an obsolete technological world, hide on planet earth disguised as cars, jets, tanks and other machines. Industrial Light & Magic produced some of the most challenging and complex visual effects shots ever to come out of the facility for the film, creating 14 photorealistic, computer animated hero robot characters.

Bay also made use of some practical puppets during filming, provided by KNB EFX. Among the puppets were head and tail sections of the giant Skorponok that transforms from a helicopter to a scorpion-like robot and attacks a special operations military unit stationed in Qatar. Though most shots of Skorponok would employ ILM’s computer generated character, the puppet tail and head allowed Bay to capture interaction of the creature in the New Mexico desert, which stood in for Qatar, and provided an on-set creature presence for a scene aboard a military transport plane in which the severed tail springs back to life.

To start the build, KNB commissioned Gentle Giant Studios to mill pieces of the art department’s computer generated designs in resin. KNB made molds from the resin pieces and created shells for the Skorponok head and tail, adding mechanisms to facilitate a few basic movements. “We didn’t go very high-tech for the articulation because we knew these pieces were going to be in sand, and that the movement was going to be pretty straightforward,” commented KNB supervisor and co-founder Greg Nicotero. “We just used radio control and cables, mounting the head on a little piston that would raise it up out of the ground.” The tail, which measured approximately ten feet long, was more of a mechanical challenge due to the overlapping metallic plates along its length. “It’s one thing to have a creature tail that’s made out of something soft; but it’s a lot more difficult to get rigid plates to collapse and slide over the top of one another as a tail is moving around. We also put a cable in the tail so it could curl up on itself like a scorpion tail.”

KNB also produced a puppet for Frenzy, a computer-hacking robot that transforms from a boom box and is featured throughout the movie. Like Skorponok, Frenzy shots most often would be accomplished via computer animation, the puppet serving only those shots requiring close physical interaction with the actors. KNB again had art department computer designs milled out by Gentle Giant. “The design of that character was very intricate,” said Nicotero. “There were a lot of sharp bits sticking out, along with speakers and rounded pieces where the CD



Teenager Sam Witwicky (Shia LaBeouf) inadvertently becomes the proprietor of his very own robot when he purchases a 1974 Camaro that, early in the film, transforms into the Autobot Bumblebee. Bumblebee served as the test-bed for the modeling, rigging, lighting and animation of all the robot characters, as well as for the

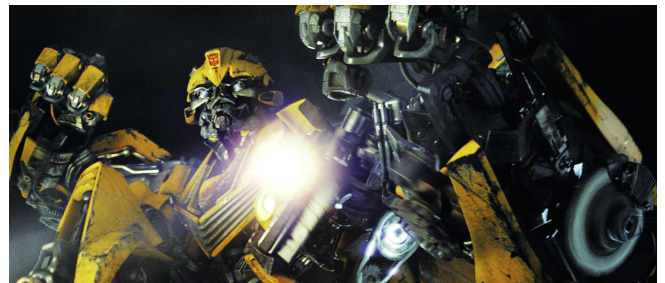
player would be. It was a pretty heavy-duty mold job, because we had to cast every single little piece. We couldn't mirror any of them. We had dozens and dozens of molds for just that one character."

The challenge for KNB in mechanizing Frenzy was that the character had been designed with an eye toward aesthetics only. "This character was never designed to really work mechanically," observed KNB supervisor Mike Deak. "In fact, some of the pieces in the computer design were actually free-floating in space! So once we got the parts out, our guys had to redesign the robot so that its joints would actually fit together. They did an excellent job of making it workable, without altering the design too much." The mandibles on the face were remote controlled, and the head and neck were on a cable-operated system to facilitate full right/left and up/down rotation. The remainder of the body was rod-puppeted, with the puppeteers in frame, removed digitally in postproduction.

The Frenzy puppet makes an appearance in a scene at a power plant, where he chases Sam and wrestles him to the ground. "For that scene," Deak observed, "we took the waist-up part of the puppet and mounted it on an offset arm so we could actually run alongside Shia LaBeouf and make it look like the character was trying to jump up onto his back. That gave the actor something to work with." In another scene, Sam's girlfriend, Mikaela Banes (Megan Fox) hacks away at Frenzy with a saw. "We made some trip-release, mechanical breakaway arms for that. When she came at him with the saw, we could hit the trip release, and part of the arm would drop away on cue."

Concurrent with the shoot, the team at ILM addressed the many challenges of computer animating more than a dozen photorealistic, hero robot characters: Optimus Prime, Megatron, Jazz, Ironhide, Starscream, Barricade, Vortex, Frenzy, Blackout, Demolisher, Ratchet, Skorponok, Bonecrusher and Bumblebee. It would prove to be one of the most difficult assignments ever to land at ILM. "You'd think that hard-body surfaces, as compared to furry animals, would be easier in CG," Scott Farrar noted, "but there is a basic rule in movies: if it isn't complex, it doesn't look complex. To make them look like real, complex characters and to give them the appropriate razzle-dazzle, every robot had to have thousands of articulated pieces and complex connections, plus layers of paint to look like car paint finishes. The swirl of the brush marks on the metal had to be there; the grease had to be there; the torch marks had to be there. Each of these robot characters needed layer upon layer of bump, texture, dirt, scratches and color."

actual transformations from vehicle to robot. ILM created 43 distinct transformations for the film, each of which required extremely complex animation and rigging, especially given the wild camera moves inherent in the transformation shot designs. Bumblebee served as the test-bed for the modeling, rigging, lighting and animation of all the robot characters, as well as for the actual transformations from vehicle to robot. ILM created 43 distinct transformations for the film, each of which required extremely complex animation and rigging, especially given the wild camera moves inherent in the transformation shot designs.



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As the Autobot with the greatest amount of screen time, Bumblebee served as the test-bed for the modeling, rigging, animating and lighting of all the Transformers. “Bumblebee had everything we were going to have to deal with on the other robots,” noted Farrar, “including the mechanical look of his face, the look of his body panels, the flaring and brightness of his lights, all the different layers of grease and dirt on his finish. Those things all first showed up on Bumblebee; and so he was right out there at the front, teaching us how to do these characters.”

Both the hero robots and their pre-transformation vehicle forms had to be modeled, the latter matched to live-action vehicles used by production. While a couple of Decepticons transform from aircraft, and Frenzy transforms from a boom box, all of the Autobots transform from land vehicles, be they an 18-wheeler semi-truck (Optimus), a black GMC pickup (Ironhide), or a 30-year-old Camaro (Bumblebee). The model team would also build a 2007 Camaro for Bumblebee, who updates his look after some disparaging remarks by Mikaela.

Where they were available, the modelers used auto industry computer models as reference for their CG cars and trucks. “We had to match all of the vehicles pretty closely,” stated ILM model supervisor David Fogler, “because in almost all of the transformation shots, the plate begins with a live-action car, then we blend to our CG car; and then the CG car transforms into the robot. The auto industry computer models were great for giving us exact proportions and scale; but we couldn’t use the data as it was, because those models are used for engineering purposes, and they are very heavy, with every single nut and bolt included. Basically, we used those models as bucks to model on top of. When we didn’t have an industry model to start with, we either scanned the live-action car or just went from photo reference.”

Initially, Fogler and his team had assumed their task would be to model the cars and trucks, and then model the robots using only the available parts of those respective vehicles. But the modelers altered course when the fantastic robot designs by the production concept illustrators began to appear. “Michael wanted our robots to look like that artwork,” said Fogler, “and we realized that we were going to have to model a car based on the live-action car; and then we would have to model a robot, independently, based on the artwork. One might not have much to do with the other — but, somehow, we were going to have to get that car to transform into that robot.”

The model crew modeled Bumblebee and other hero characters in Maya, matching to the artwork, delivering what they thought were final models in October 2006. “We thought we were done at that point because our models looked like the artwork,” stated Fogler, “but Michael Bay looked at them, and said, ‘Not even close.’ He thought they looked too fantastic, too science fiction, and not nearly believable enough. It took us a while to figure it out, but we finally realized that they needed more recognizable car parts. Michael wanted to see hoses, hose clamps, distributors — anything that the viewer’s eye could land on and recognize as a real car part.”

At that point, ILM’s modelers and the viewpoint team — led by Ron Woodall — collaborated to build a huge library of automobile parts. “You name it, and it was in there,” noted Fogler. “We just Googled ‘car parts,’ and got reference for all these parts — oil filters, air filters, hoses, clamps. We must have had a thousand images, and from those we built this library of painted, fully detailed hero auto parts. Then we began stuffing our robot models with these parts. The robots nearly doubled in

density from this process — and this was after we thought we were done with them! It was really worthwhile, though, because the robots made huge leaps in terms of their look and complexity.”

In the end, each of the robot models was comprised of thousands of pieces of individually modeled and painted geometry. “I don’t think we’ve ever had this number of pieces in a character before,” said digital production supervisor Jeff White. “All of the Transformers together had more than 60,000 moving parts, and about 12.5 million polygons. We figured out that if you lined up the pieces of all the Transformers end to end, they’d stretch about seven and a half miles. Optimus alone had 10,108 movable parts — and that doesn’t include his truck form. Bumblebee was comprised of 7,608 separate parts. Megatron had about 4,000 parts. There were some pieces that were shared between robots; but by and large, all of those pieces were individually modeled.”

From the modeling department, the car and robot models went to creature development for animation rigging, which, due to the complexity of the models, would be a labor-intensive, difficult assignment.

“We’ve done robots before,” White commented, “but never like this. We did battle droids for *Star Wars*, for example, but they had far fewer pieces; and because there were so few pieces, we could decide ahead of time how each piece would move. We couldn’t do that with these Transformers. They were so complex, there was no way to build a rigging system ahead of time that would accommodate all of those pieces moving in all of the shots. Instead, we came up with a system that had multiple layers. At the base layer was our standard hierarchy for animation controls; and on top of that we had a layer of rigging to automatically drive the pistons and gears.”

Another layer of rigging added scale-selling vibration to larger body panels as they moved — the ‘waga waga’ factor Stan Winston and his team had fought against in their full-size mechanical dinosaurs for *Jurassic Park*. The final layer of rigging — and one of the most important breakthroughs in the Transformers project — was termed ‘dynamic rigging,’ a system of controls that enabled animators to move every piece of geometry on the model, independently and by hand, even if that piece had not been rigged for animation originally. “It would have been impossible for the riggers to anticipate every single thing the robot was going to do and to rig all of that up beforehand,” explained animation supervisor Scott Benza. “For example, as we were animating, parts would often interpenetrate — which was inevitable, given how many parts were in these models. To have to kick that model back to creature development every time would have been a tremendous pain. Instead, our creature supervisors developed this set of tools that allowed the animators to create rigging on the fly, on a shot level rather than at the show level. Our team wrote them as Maya plug-ins integrated into our pipeline, and they gave our animators a crucial level of control.”



Caught in the middle of warring Transformers, Sam is chased by the Decepticon Barricade. ILM artists modeled all of the Transformers in Maya, matching the high-tech look in designs provided by production concept illustrators. Michael Bay’s dissatisfaction with the first-pass models prompted the ILM team to significantly increase their complexity and gritty quality by incorporating hundreds of recognizable auto parts – such as distributors, hoses and oil filters – into the CG characters. Final models were the most dense and geometry-heavy ever created at ILM, each featuring thousands of articulated, uniquely modeled and painted parts.

The transformations themselves presented the most challenging animation rigging problem — and the task became even more problematic as the animators began to realize that each character would need more than one transformation design. “At first,” commented Benza, “I thought we’d be able to do one transformation per character, and just show that same basic transformation from different camera angles in multiple shots. But we started to realize that to make them as interesting and as cool as possible, each transformation had to be designed to camera, specifically for that camera angle and movement. We had to have a unique, completely different transformation every time a Transformer transformed in the movie. We ended up doing 43 separate transformations, all designed to camera.”

Complicating the matter even further, none of the transformations was a locked-off shot, with a static car transforming into a static robot in front of a static camera. “Every time there was a transformation,” Russell Earl explained, “the camera was moving all over the place — between the legs, around the foot, up around the head — and everything on the character was moving, as well. There’s a shot where the camera goes through Bumblebee’s legs as he is transforming, and you can see that all the gears are turning, and springs and chains are moving. Transformation designs like that meant that we couldn’t hide anything. We quickly realized that we were going to have to detail these robots everywhere. Fortunately, we were able to get a lot of great detail out of paint. We’d see a piece that needed more detail, and Ron Woodall and his team would patch it up with paint and some bumps and textured detail that saved us from having to model another piece.”

For each transformation design, artists started with the robot in its final, standing position, then worked backward, animating movements that would take the robot to a crouched position, closer to the ‘all fours’ stance of the beginning vehicle. After blocking in that broad-stroke choreography, the animators found appropriate actions for the limbs and other big pieces of the robot puzzle that had to move into place on the vehicle. “We’d find a way to detach an arm, for example,” said Benza, “and get it to fold in an interesting way so that it would go neatly to its place on the vehicle. We went to a more detailed level from there, finding actions for smaller pieces of the model. We just broke it down from big chunks to medium-sized pieces to the fine detail pieces.”



*While ILM was the primary vendor on the picture, Digital Domain contributed scores of shots, including those showing the Transformers’ arrival on earth as crashing asteroids. Digital Domain developed effects animation to create the look of lava-like rock flaring as it burned off in the atmosphere. Asteroid impacts, originally slated as full-scale or miniature pyrotechnic gags, were realized entirely through CG, aided by tools and techniques Digital Domain had developed for Clint Eastwood’s war picture, *Flags of Our Fathers*.*

Because the Autobots and Decepticons take the form of bipedal characters, Benza had assumed at the start of the project that motion capture would provide the basis for much of their performance animation, post-transformation. But when the animators presented Michael Bay with early motion capture animation tests, the director expressed dissatisfaction with the look. “Michael thought the animation was uninteresting,” said Benza, “and that it looked like guys in suits, without the weight of the characters that should have been there. As a result, motion capture played less of a role than I had assumed it would. We used it for low-action types of performances of robots standing around or aiming their guns; but all of the more dynamic, athletic action was keyframe animated.”

For the most dynamic fight moves, the animators relied on martial arts reference Bay shot on stage at Digital Domain. “It took us by surprise, at first, to realize how much athleticism Michael wanted out of the robots,” Benza stated. “We’ve never seen robots do martial arts fighting moves before, and having the fight reference was really important to getting all of us to understand what Michael wanted. Of course, that athleticism worked against selling their weight and scale; and so we had to find our moments to sell the weight. We learned that the farther they were from camera, the more slowly we had to move them. The closer they got to camera, the more we could get away with doing faster motions, mainly because you weren’t seeing the entire robot in frame. Slow motion was also a big help on the film, because you don’t question the scale of things quite as much when they are moving in slow motion.”

To ensure each robot would have its own distinct personality, Bay pointed the animators to specific actor reference. Michael J. Fox as he appeared in the *Back to the Future* movies provided personality reference for Bumblebee. “We did an Optimus facial animation test using Liam Neeson’s performance in *Kingdom of Heaven*,” Benza recalled, “and Michael responded very well to that. One of the tests for Megatron was based on a Hugo Weaving performance. We did a few of these facial tests early in production to get a sense of how realistic Michael wanted the facial animation on the robots to be. He didn’t want them to be generic ‘big, dumb robots,’ as he called them.”

A hard and fast animation rule on the show was that the animators would never ‘cheat’ a facial expression by deforming a piece of geometry. The rule maintained integrity in the animation, but it meant that, especially to create facile expressions, the robot head models required a very large number of small, movable pieces. Optimus’ face alone was comprised of more than 200 pieces, among them metal bars across the eyes at the top and bottom that could scissor up and down, simulating a blink. “I was very keen on moving things around the eyes and the upper cheeks,” observed Scott Farrar. “It still looked very mechanical, but it enabled us to create facial expressions



Digital Domain also created shots for a flashback sequence in which Sam’s grandfather, guiding an Arctic expedition, discovers the Decepticon leader, Megatron, encased in ice. Digital Domain extended a bluescreen cave set built at Playa Vista by production designer Jeff Mann with plates shot by a second unit in Alaska. For 3D views of Megatron within the cave, Digital Domain added special lighting and icy textures to ILM’s Megatron model.

and emotion in these characters. I also wanted to make sure we had segmented pieces on the mouth — three upper pieces and three lower — so if the robot had to form an ‘o’ shape with mechanical lips, he could do that.”

Animators studied videotape of Optimus voice actor Peter Cullen speaking the dialogue to create the appropriate lip-sync animation. “Michael didn’t want us to use that video for performance reference,” remarked Benza, “but it was important for us to see how Peter Cullen’s lips were moving, to see what his mouth was doing when he spoke the dialogue, so we could transfer that to Optimus’ virtual performance. We needed that with Optimus more than the other robots because he was a lead character, with a lot of dialogue.”

Lighting was as crucial as the animation in creating credible Transformer characters. Having spent years directing commercials, Michael Bay was well schooled in the intricate and painstaking lighting required to show cars off to their best advantage; and, with director of photography Mitchell Amundsen, he utilized every lighting tool and trick available to create highlights and sweet spots on the live-action vehicles. In Transformers, the CG vehicles — and their robot forms — had to be lit just as artfully to make them appear as cool and sexy as possible. “I spent as much of my time as a director of photography on this movie as I used to do in live-action,” commented Scott Farrar. “We used key and fill lights, bounce cards, reflectors and gels. We used flags and barndoors to create hard-edged shadows. It was all synthetic, but the job was exactly the same as in live-action. It was the only way we could get the robots to look like they had actually been on the set when we shot the background plates.”

The high-resolution representations of lighting environments captured by the on-set crew were key to achieving that goal. While acquiring such lighting environments is standard operating procedure on effects movies today, ILM strove for a level of detail in those representations far beyond what had been attempted in past shows. “We used to go to 1,000-pixel resolution texture maps,” noted CG supervisor Hilmar Koch, who oversaw the lighting, “but on this movie, across the board, we always used 8,000 pixels. That was a major component to getting the lighting to Michael’s satisfaction. Capturing all of this high-resolution data on the set was more labor-intensive on the front end; but it streamlined the job at the back end of shot production, because we had to spend less time getting external reflections here and there — we would just use the really high-rez environments for those.

“Also, when we had the spherical environments to use as lights, we didn’t have to use full ray-tracing; and so rendering became relatively cheap. We’d just turn on ray-tracing for the parts that needed it — for example, the chrome parts on Optimus, which were particularly reflective. Every part of the robots and cars was reflective to one degree or another; but what we learned early on was that we could get away without ray-tracing on the more weathered metals, since the reflections



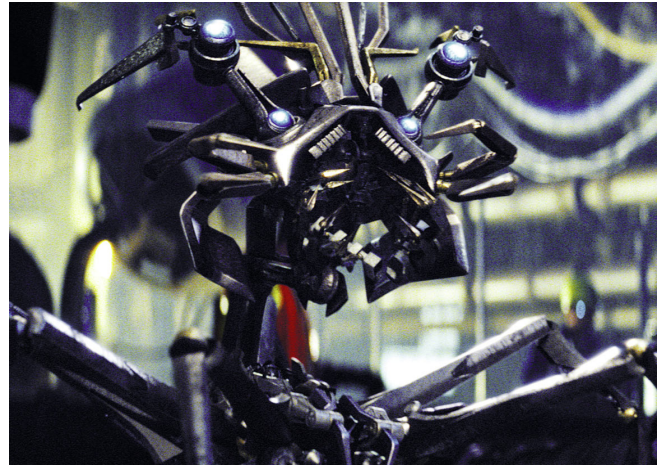
A tour of a top-secret facility hidden beneath Hoover Dam reveals the giant All Spark cube that imbues technological devices with life. ILM created the All Spark holding area entirely as a 3D environment, based on concept artwork generated by the production and at ILM. ILM incorporated animated elements into the fully textured digital environment, as well as practical elements shot at Kerner Optical – such as smoke, steam and sparks – and performers filmed against bluescreen. All of the elements were composited in Shake.

weren't as crisp as they were in the chrome. So we wound up being able to use this hybrid approach, using environment lighting for the rougher metals, and doing ray-tracing only for the most reflective parts. The interchangeability of lighting reflections and ray-trace reflections, being able to go from one to another easily, was a big step forward."

Photorealistic lighting also required shaders that would duplicate the effects of illumination on the live-action vehicles' surfaces — how the car paint reacted to light, how much it reflected, what colors it reflected, how metallic it was, and the density and quality of specks in it. Shaders also had to re-create the pristine finish of the real vehicles, some of which — such as the 2007 Camaro — were buffed to a high shine between every take. Sequence supervisor Doug Sutton developed a range of sophisticated shaders that simulated the high-tech, multilayered paint finishes currently used on automobiles and trucks. Robot finishes, which were less pristine than their vehicle forms, featured viewpainted textures that served to age them and make them look as if they had suffered combat wear and tear.

One of the most difficult robots to light, in both robot and vehicle forms, was Ironhide, a weapons expert who transforms from a black GMC truck. Not only was it difficult to make the black character show up against backgrounds — especially at night — the model was one of the most geometrically dense, featuring detailed gun models that, alone, were heavier than some entire robot characters. In a pivotal nighttime scene, Ironhide joins all the other Autobots in hiding in the prized Witwicky garden. “Michael had these robots standing around, talking to Sam and each other, and you stare at them in their full detail for a long time,” Hilmar Koch commented. “It was one of the hardest sequences to light because you had to see all of these garden lights reflected in the robots. Then, when they approach the house, the lights shining from the inside spill a warm light onto the robots. Also, Michael had this huge illuminating balloon overhead that gave everything a bluish moonlight base level; and that was also very difficult to get right in our lighting.”

In some cases, ILM was able to simplify the lighting in areas of the robots, adding reflections through compositing techniques, rather than ray-tracing or using the high-resolution environments. “If things looked a little dead in a certain area,” explained compositing supervisor Pat



Transformed from a boom box, the troublemaking Frenzy provided the movie with comic relief. Although ILM produced the majority of the Frenzy shots, Digital Domain contributed shots of the character after its head is cut off with a saw, starting with ILM's model and textures to ensure an exact match between the pre- and post-decapitation robot.

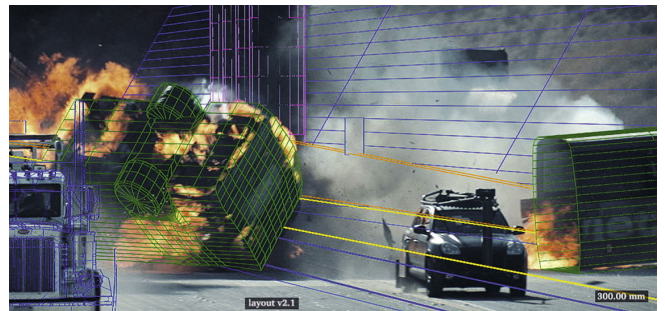


For specific shots requiring close physical interaction between the character and live actors, KNB EFX built an animatronic Frenzy for use on set. Mechanical technician Jeff Edwards and project supervisor Mike Deak fine-tune the completed rod puppet.

Tubach, “or if it wasn’t quite working, we could either have the TD manipulate the reflection environment and put something in there, or we could just go in and put something in that sweet spot in compositing. For example, there are shots where Sam and Mikaela are riding on Optimus’ shoulders. The shadows and reflections of the kids had to be massaged in order to make those shots work with the complicated geometry of the robot. Optimus had large chrome pipes on the shoulders that reflected everything; so we figured out where we would see the kids in there, and then wrapped their images around the pipes in the comp.”



For a kinetic Autobot-vs-Decepticon freeway battle, ILM integrated its CG Transformers with live-action plates featuring large-scale explosions, fires, clouds of dust and debris, all provided by special effects supervisor John Frazier and crew. To create a shot of Autobot leader Optimus Prime facing off against Bonecrusher on the freeway, ILM started with a plate in which Frazier had rolled and ignited a semi-truck. ILM executed a truck-to-Bonecrusher transformation, tracked in the computer animated characters, and digitally enhanced the on-set effects mayhem.



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With very few bluescreen elements to deal with, Tubach initially pegged Transformers as a relatively simple, straightforward project in terms of compositing. But as elements and plates started coming in, Tubach and his team recognized that it was going to be a major compositing task to create a sense of interaction between the robots and the environments. “The robots weren’t just going to be standing around,” remarked Tubach. “They were going to be touching everything, smashing into things. There was also the challenge of working on eye-lines, and making sure everything lined up so that it really looked like the actors were talking to the robots. Most of that was taken care of in animation; but sometimes we had to manipulate the plates during compositing to help that along.”



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No sequence required a more artful integration of CG robots into environments than one near the end of the film, when Megatron and Optimus engage in combat in and above the streets of Los Angeles, plowing through buildings and raining debris and damaged robot parts on the crowds below. Though Bay shot explosive, special-effects-filled plates for the sequence in downtown Los Angeles, some of the wilder camera moves required all virtual backgrounds, created by the digimatte team from a sphere of images shot by cameras hung off the sides of buildings.

Rigid body simulations helped to create Optimus’ and Megatron’s dynamic interactions with the environments, both live-action and virtual. “Most of our simulation work on the show was for destruction and robot damage,” said Jeff White. “It was very important to Michael Bay that these robots really look as if they were in the environments, and that required a lot of interactions, with robots kicking things over and blowing stuff up. We looked at each shot and made decisions as to what stuff we were going to move in that plate, or what things we might add to it. We might add a light pole for the robot to knock over, or bits of concrete flying down on them. In one shot, a jet flies through the street, and we had the trees blow a bit behind it. Sometimes, even if the characters were just walking on the ground, we’d add pebbles to provide some interaction with the pavement. In more aggressive shots, we’d rip up the pavement and break walls and signs. Those little things sold the weight of the robots and their presence in the environment.”

As the show progressed, ILM modelers built a library of debris that could be parented to the simulated explosions to make them look as photorealistic as those orchestrated on the set by John Frazier. Opened up in Maya, the debris model would stretch out to the horizon, comprised of pieces of concrete, plaster, lathe, rocks, post boxes, parking meters, and



smashed-up building structures, such as fire escapes. “The sim would just have basic polygonal shapes,” stated David Fogler, “and then those shapes would be parented to these hero models — and all of this photoreal debris would come out of the simulated explosion. We were very happy with how that turned out; and so now we’re developing more complex and easier ways to link together the simulations and these hero painted models. We’re looking into automating that process so we could say, ‘This explosion needs things of about this scale’ — and the program would go to the library and find appropriate bits of debris. It’s not quite that sophisticated yet, but it will become more automated as we develop it further.”

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The CG debris and simulations augmented not only Frazier’s on-set special effects, but also pyrotechnic and other elements shot at Kerner Optical, the now independent company comprised of members of ILM’s old model shop. Under the supervision of Brian Gernand, Kerner also built miniatures featured in the city street fight, shot by director of miniature photography Pat Sweeney. For a shot of Optimus and Megatron smashing through a building, Kerner built a replica of the plate building in quarter scale, which measured 20 feet wide, 25 feet long and more than 15 feet tall. “I think the reason Scott Farrar and Michael Bay decided to shoot this using a miniature was because it’s an extremely high-action moment,” noted Gernand. “Optimus and Megatron are flying down the street, doing battle in the air; and they plow straight into the building, destroying four floors of dressed miniature as they travel through, and then burst out the other side. Michael really wanted to see the action. He wanted to see them going through the building, not just going in and then coming out the other side.”

Matching to the existing Clinica Building that production had shot in downtown Los Angeles, Gernand and his crew built a miniature structure with large Corinthian columns, breakaway brick-and-mortar walls on the exterior, and hundreds of pieces of quarter-scale office furniture on the interior. “It was designed to look like an architecture firm,” Gernand explained, “with open loft spaces filled with drafting tables, file cabinets, bookshelves and lamps. As the robots go through the building, they churn all of this furniture in front of them.”

To create the necessary interaction on the miniature, the Kerner crew built a mandrel representing the two interlocked robots, cantilevered out into the middle of the stage on an arm. That arm connected to a giant sled that was motivated by a hydraulic ram. “The same ram that motivated the robots also motivated the camera on the sled,” said Gernand, “so the camera and the robots were locked in the same position. As the sled took off, the robots tore through the building, and the camera stayed with them for



The gun-toting Ironhide fires on Decepticons in the movie’s climactic sequence – a huge fight between the Autobots and the Decepticons in the streets of Los Angeles. Though

that side view. There was a very specific path of destruction the robot mandrel went through, and a very specific exit point, as well. Everything they hit on the entrance, through the building, and at the exit was breakaway.”

Michael Bay complicated the miniature destruction when he requested that there be no attendant dust, so that the action would be clearly visible. To keep the pyrocel used in the columns and other structures from exploding into dust on impact, the model crew hydrated it via a garden drip system installed just above all the impact zones. “We’ve learned through the years that if you keep pyrocel hydrated, it creates a lot less dust,” Gernand said. “So we installed this drip system into the pyrocel on our miniature. We’d turn that on and let it go for hours; and by the time the mandrel smashed into the pyrocel, the columns broke with great scale, but there was virtually no dust. We did the same thing at the exit point.”

For the interior sections, the crew installed trip wires and a network of cabling into breakaway floors and ceiling panels made out of a paper product that resembles concrete when it breaks into pieces. Above each prescored floor was a laser-cut truss system made out of thin wood, and I-beams made from heavy gauge foil. As the mandrel passed through, it broke the floor and ceiling panels, then the truss work, then the twisted foil I-beams. The crew also installed real 1/16-inch breakaway glass in the building windows.

To capture the action, Pat Sweeney aimed six cameras on the building miniature from a variety of angles, in addition to the camera-and-mandrel sled mount, which special effects supervisor Geoff Heron engineered to travel from zero to approximately 30 miles per hour in less than a second, then come to a dead stop within ten feet of exiting the building to avoid hitting the stage wall. Camera frame rates ranged from 36 to 96 frames per second.

Michael Bay shot dynamic plates for the sequence in downtown L.A., scenes featuring physically impossible camera moves required all virtual backgrounds, created by ILM’s digimatte team from images photographed from the sides of L.A. buildings. ILM employed rigid body simulations to create physical Transformer interactions with both live-action and virtual environments, raining debris and damaged robot parts onto the streets.



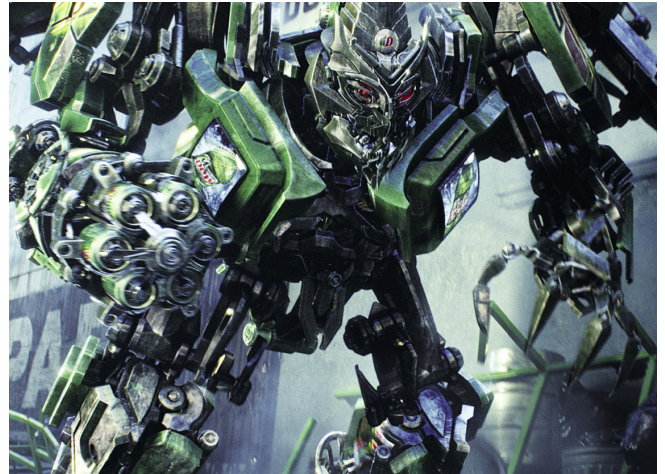
A helicopter-bot, Blackout, joins the street fray. An on-set ILM crew captured extremely high-resolution representations of every set and location during principal photography, enabling the effects team to exactly duplicate the lighting on CG characters and environments.

The entire miniature setup had to be reset for a second take, as requested by production. “We were asked to do it twice,” said Gernand, “so we designed it so that all of the breakaway parts would come out. Then we had an entire second building that took us a few days to set for Take 2. After Michael saw the footage from Take 1, he had us move the cameras around and add a couple more. We wound up with ten cameras capturing this event over the course of two takes, which gave him a tremendous amount of footage to work with.” To populate the miniature, ILM compositors dropped in greenscreen elements of running and ducking crew members.

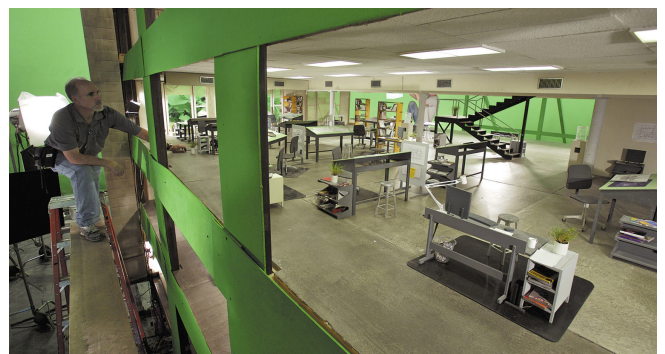
The street fight intensifies when Megatron chases Sam as he attempts to reach the roof of a defunct train station with the precious ‘All Spark’ cube, an artifact of the Transformers’ planet that imbues mechanical objects with life. Sensing Sam on the floor above him, Megatron bursts up through the floor and swipes at the boy, smashing a series of statue columns. Production shot live-action for the sequence in a Detroit train station. To accommodate the robot action, Kerner built the statues and a section of the train station floor as a 1/3-scale miniature, which measured 24 feet long, about ten feet wide and five feet tall. “They had filmed the floor bursting and the explosion live-action,” remarked Gernand, “so we didn’t have to do that part in miniature; but we created the action of Megatron swinging his arm and smashing these five beautiful art deco statues. We built our set for two takes — so we needed ten statues that we could destroy.”

Kerner started with a fiberglass casting of the full-size live-action statue, which sculptor Richard Miller replicated by eye. The crew then molded the clay sculpture and cast it in tinted pyrocel. Cylindrical columns on the left and right side of frame and a wrought-iron railing completed the miniature. To break the statues on cue, Geoff Heron’s crew attached to their backsides pneumatic rams connected to steel plates that conformed to the statue shape. The plates were on a sequencer, which pushed them forward in quick succession, breaking all five statues, within one second. Sweeney captured the action with an overcranked camera to help the scale.

Digital Domain — the effects powerhouse that Michael Bay had purchased in 2006 — also contributed to the street fight and other sequences in Transformers, taking on 95 of the film’s 600-plus shots. “Understandably,” observed Digital Domain visual effects supervisor David Prescott, “Michael didn’t want to pull any of the hero transformers from ILM, because it would have been difficult to share those characters and shots across two



The Mountain Dew bot – the result of a soda vending machine’s being zapped by a piece of the All Spark cube – also makes an appearance in the final street battle. Digital Domain had only four weeks to model and animate the character, due to its late addition to the street battle.



[illegible]

the All Spark cube by zapping a cell phone in a started with clean plates of the actors around and a robot part to put in there for color and with nothing inside the box. We also shot re-create the lighting.”

“So, animation supervisor Dan Taylor and I labored as it had appeared in the art department. “What’s going to happen in this scene,” said Dan. “What had to do — what functionality did it need? It was supposed to be this very nimble, fast character. We streamlined the legs. We also gave it a set of arms. Because of the time crunch, we actually didn’t have any design issues as we went along.”

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Just as ILM had, Digital Domain found that their transformations required complex rigging, much of which had to be created simultaneously to the animation. “We couldn’t just pick and choose beforehand which pieces of geometry we wanted to transform,” said Dan Taylor, “because the animators didn’t know that information until we got in there and started doing it. Since we didn’t have all the answers as to how these things might transform and what they might do, we just made sure we always had our rigger, Paul Jordan, there. There was a base rig for all of these things, but Paul added the necessary rigging for whatever features we discovered we needed as we went along.” Animators Eric Petey and Dan Patterson led the transformation shots, identifying major moving components, and then blocking in the movements of smaller pieces of geometry. “It almost became a textural thing at times, and we were able to get away with a lot of cheats. We knew that it didn’t have to make sense physically and mechanically; it just had to look like it did.”

Near the end of the Nokiabot scene, the camera moves in for a closeup on the transformed character. Encountering depth-of-field problems on the background due to the extreme zoom, Digital Domain repainted the background to add resolution. The crew also corrected depth of field on the disk that the character stands on inside the box. “We brought that disk back here,” related Prescott, “put it up on stage, relit it and did kind of a cheap man’s translight. We took digital photographs of the inside of the cube, printed them out onto paper, and then set that up on stage behind this plinth and just projected light back through it to get the correct reflections onto the cube and disk. This was four months after the shoot — and it worked perfectly.”

A number of Digital Domain’s shots involve robots that transform out of everyday objects when they are zapped by the All Spark cube during the street fight finale. Digital Domain started with designs from the production concept illustrators, which were then modified by Stan Seo for modeling and animation in CG. Among the street fight Transformers is the Mountain Dew robot that transforms from a vending machine. The biggest challenge with the Mountain Dew Transformer was that, after being deleted from the film, it was added back in just four weeks prior to Digital Domain’s delivery date. “It was a real scramble to get it done on time,” commented Prescott, “and it was a transformation shot! He also had a lot of effects work associated with him — smoke and muzzle flashes as he shoots soft drink cans from his big guns.”

Also added late in production were two finale shots of a life-infused X-box being carried away by a looter. Due to the extreme time crunch, Digital Domain modified its existing Frenzy model to make it look like an X-Box Transformer, rather than build a new model from scratch. “We animated it in Maya,” said Dan Taylor, “and that Maya file became the master file. All modifications were done directly within that file.” The same sequence features an Escalade steering wheel that comes to life and grabs hold of a driver’s face. Production shot the inside of the car without the steering wheel so that the effects artists could more easily add it later. The animation has the steering wheel opening like a flower, then splitting in two and growing claws, transforming into an *Alien*-like facehugger that springs from the steering column.

In addition to its Transformer shots, Digital Domain contributed to flashback sequences set in the Arctic, where the expedition led by Sam’s grandfather is trapped in an ice pack. Later, the elder Witwicky falls into a cave, where he discovers Megatron frozen beneath the ice. Digital Domain extended a bluescreen cave set at Playa Vista with background plates shot by a splinter group in Alaska. For 3D views of Megatron within the ice cave, Digital Domain added special lighting and icy textures to ILM’s Megatron model. A long zoom in on Witwicky’s eyeglasses, etched with alien text, required digital augmentation, as well. “We shot a plate for that,” recalled Prescott, “but the zoom had to go way beyond what we could photograph. So lead compositor Joe Farrell reconstructed the entire foreground of the plate digitally using Nuke, and replaced it with painting and 3D work.”

Digital Domain also produced shots of the Transformers arriving on earth in the form of crashing asteroids, developing effects animation to create the look of lava-like rock that flares as it burns off in the atmosphere. One shot has four robot asteroids flying over Griffith Observatory. Production had shot a plate at the Los Angeles landmark; but foggy weather conditions required that Digital Domain paint out the fog and add back in matte-painted detail. Digital Domain also added CG

effects and practical elements from its library to a plate shot at Dodger Stadium, simulating an asteroid crash-landing on the playing field.

Production had shot a foreground practical gag to suggest the impact of one of the asteroids in an open field, but Digital Domain replaced the special effects crash. Initially, Prescott had intended to shoot a miniature for the impact, to better capture environment interactions; but conversation with artists who had just come off *Flags of Our Fathers*, for which Digital Domain had created photorealistic CG explosions and debris, led him to consider a digital approach. “These guys who had worked on *Flags of Our Fathers* were completely confident that we could do it all CG,” said Prescott. “I wasn’t completely sold; but we had a couple of weeks before we had to shoot a miniature, so I told them to see what they could do in the meantime to convince me. Within a couple of weeks, I was completely convinced that we could achieve it all in CG. It had to be done in time for the teaser trailer, so we threw a ton of resources at it and got it to a good state. Then we went back in for another month and really detailed it out.”

Digital Domain ended up adding countless explosions, missile hits and debris — what the team dubbed ‘Bayhem’ — to the asteroid impact shots and other sequences, producing most of the work in Houdini and using Houdini’s Mantra as its primary renderer. “On a couple of shows in the past, we’ve had cases where it would have been better for us to be able to light from within Houdini,” noted Prescott. “But we never developed a pipeline for it. This show, because of its size and the type of work it involved, seemed like a good opportunity to develop a lighting pipeline in Mantra that we could use on future shows.”

While the environments and effects animation work on Transformers serve to promote Digital Domain’s reputation as a first-rate provider of photorealistic digital environments, the facility’s artists hope that the film industry will take notice of its 3D character work on the show, as well. “There’s always been a kind of labeling with effects houses,” observed Dan Taylor. “One house is labeled a creature animation house; another house is labeled an effects house. One of the reasons that I came to Digital Domain was to try to help change the label. Digital Domain has always done some of the very best environmental stuff; but I wanted a chance to add creatures to what they do. My hope is that this film will go a long way towards promoting the fact that Digital Domain is not just an effects house — that we can do world-class creature animation, as well.”

Long known for its character animation, ILM only confirmed its standing with the completely convincing and fantastic robots in Transformers. “Transformers was a great opportunity to turn out some really spectacular work,” stated Scott Farrar. “I come from a photographic background, and I’ve witnessed the long struggle to make computer graphics subjects look photoreal. I think we really turned that corner on this picture. The whole project has been surprising for all of us in terms of how much we could get out of these hard-surfaced subjects and how exciting the images could be. We were aiming pretty high, but I think it exceeded our expectations. We’re all thrilled with it.”

Especially thrilled were those young animators and technical directors for whom the project was homage to favorite childhood characters. “In the end,” concluded Shari Hanson, “these were robots created with love by their fans.”

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Army of Darkness

image

ARTICLE BY JOE FORDHAM

Ten days prior to the publication of the seventh and final novel in J.K. Rowling's boy wizard saga, Warner Brothers unveiled the fifth entry in its ongoing movie franchise, *Harry Potter and the Order of the Phoenix*. Like its predecessors, the film condensed and excised subplots to focus on Potter's struggle against the reborn, evil Lord Voldemort (Ralph Fiennes). Harry (Daniel Radcliffe), now a rebellious teen, forms an alliance with fellow students at Hogwarts School of Witchcraft and Wizardry to counter the insidious effects of Voldemort's return — encountering the dictatorial Professor Dolores Umbridge (Imelda Staunton) and eventually the Dark Lord himself in a fierce wizard battle in the bowels of the Ministry of Magic.

Preproduction dovetailed into postproduction of the previous Potter film at Leavesden Studios in England, retaining many cast and crew members. Series veterans included production designer Stuart Craig, special effects supervisor John Richardson and makeup and creature designer Nick Dudman, while visual effects supervisor Tim Burke returned for his fourth Potter assignment, working alongside visual effects producer Emma Norton.

Guiding the enterprise was British film and television director David Yates, his first time at the helm of a major visual effects production. "The fifth book gave us an opportunity to move away from Hogwarts to London," commented Tim Burke. "We used computer graphics to create sets bigger than we could create practically, which was a new approach for a Potter film." New environments included the Ministry of Magic, the underground headquarters of the wizard civil service in London. "David wanted the audience to believe that this magic place really could exist in London, so Stuart Craig designed a huge subterranean environment heavily influenced by Victorian London Underground train stations, with a ceramic detail tile motif. We were referencing the real 'muggle' world to try to create as much believability as possible."

Location work included scenes in Central London and second unit aerial photography above the River Thames, used as background plates for flying scenes above the city. The production also filmed in Scotland to depict rugged highland scenery surrounding Hogwarts castle. "My second-unit supervisor, Chris Shaw, went up in winter to shoot plates for snowy scenes," said Tim Burke. "We then had a team return in summer to shoot the rest of the aerial and ground plates. This time we didn't take actors up to Scotland. We just built a small hill on the back lot at Leavesden, and put bluescreens around it. Anytime we saw Harry and his friends running about on the hill we put in Hogwarts and Scotland environments beyond."

The production created Hogwarts using standing sets at Leavesden and an expansive 1/24-scale miniature, built and maintained by Cinesite's team of 50 modelmakers at Shepperton Studios. Modelmakers retrofit conical roofs on a portion of the castle, adding taller, spikier towers for a menacing camera pullback from a window framing Hogwarts' sinister Professor of Potions, Severus Snape (Alan Rickman). Director of miniature photography Nigel Stone oversaw approximately 20

miniature shots filmed using Ian Menzies' Wotan rig to facilitate camera moves around the 27-foot-tall structure.

Beyond Hogwarts, the environment included establishing shots of Hogsmeade — a Dickensian highland haven for wizard students on off-campus furlough — seen as a precarious mountaintop location. Production built a full-scale 'High Street' portion of the village at Leavesden. Cinesite then constructed a 40-by-30-foot, 1/16-scale miniature to expand the environment. "The art department produced a tabletop model of the village and drawings," explained miniature effects supervisor José Granell. "We built the entire village and the outcrop of rock that it sat on, right down to interiors of shops. It was a lovely model, with curves and overhangs and slumps to all the buildings that snaked up the hill." Modelmakers built structures out of wood, laminated with micro-plaster sheets of stonework and roof tiles, then mass-produced windows, dormers and doorways in fast-cast resins and dressed the terrain with a layer of artificial snow.

Double Negative The Moving Picture Company, Industrial Light & Magic, Cinesite and Rising Sun Pictures composited miniature elements into Scottish scenic plates. For interior views of Hogwarts' main atrium, a miniature moving staircase used in previous films was retired in favor of a digital approach. MPC created the staircase as a digital construction populated with bluescreen performers and a gallery of living oil paintings generated at Cinesite.

Production also favored digital over practical creature effects, though Nick Dudman's team remained key contributors in maquette production. In-camera creature gags included a magical potted plant belonging to Hogwarts student Neville Longbottom. Dudman's crew constructed a foam rubber animatronic cactus with a self-contained radio control mechanism that allowed the plant to emote as Longbottom wielded it in scenes. Harry's trip to Hogsmeade also featured a wall-mounted boar's head trophy, in the Hog's Head Inn, mechanized to convey a disgruntled demeanor.

Larger inhabitants of Hogwarts' Forbidden Forest included 16-foot-tall skeletal winged steeds known as 'thestrals,' and a herd of half-horse/half-human centaurs. "There was no way on God's earth we were going to build an animatronic thestral," remarked Dudman. "And there were so many centaurs, we knew it would be daft to do them any way but CG. So we sculpted maquettes and scanning models, and visual effects extrapolated from those."

Production used a portion of a full-scale thestral sculpt for characters to sit on atop a motion base flying rig, known as the 'M-rig.' Developed by Framestore CFC and employed, with The Visual Effects Company motion control, for an airborne creature ride in the third *Harry Potter* movie, the M-Rig was adapted for scenes of Hogwarts students riding on the backs of flying thestrals animated by ILM. "We used the same technology developed for the hippogriff in *Harry Potter and the Prisoner of Azkaban*," said Tim Burke. "Chris Shaw programmed the motion control and we shot actors against bluescreen or greenscreen. Previously, we had built an articulated neck that actors could hold onto, and it was sometimes restrictive for our animation. This time, we designed the rig so the actors held onto fairly rigid parts of the body, with a basic backward and forward movement, without committing us to details that could over-complicate the shooting process."

The screenplay eliminated Quidditch tournaments from Rowling's narrative, but contained broomstick flights and levitations that made use of the production's physical effects rigs. "We upgraded all of our pole arms and broomstick flying rigs," remarked John Richardson. "We had a lot of interactive effects where characters were floating, rolling through the air or being picked up by CG-animated creatures. So we had to pick up actors following pre-set patterns of movement married with CG, and a lot of that had to be programmable. We could tie our rig to visual effects so they could trigger it; or if visual effects did a previz, we could use their data to program the move and repeat it every time. We made body molds for the actors and attached them to our pole arm so we could pick them up using different harnesses to keep their center of gravity in the right place. We used the same rig for broomstick flying."



Harry Potter's troubles return before his fifth year at Hogwarts when two dementors invade the non-wizard 'muggle' world and attack Harry (Daniel Radcliffe) and his cousin Dudley Dursely (Harry Melling). Harry Potter and the Order of the Phoenix, directed by David Yates, reunited many cast and crew members from previous Potter films, including production visual effects supervisor Tim Burke. Makeup and creature designer Nick Dudman redesigned the dementors in maquette form. Physical effects supervisor John Richardson propelled performers about the set using levitation pole-arm rigs, and Industrial Light & Magic computer generated the revamped dementors.

Trouble begins at Potter's muggle home on Privet Drive when Harry and his cousin Dudley Dursely (Harry Melling) see strange clouds gathering over a local park. David Yates filmed the scene on the backlot at Leavesden, and ILM's digimatte department generated a supernatural sky. "We took photographs of real cloud textures," said ILM visual effects supervisor Tim Alexander. "We placed them onto multiple cards and warped them. For closeups, we shot fiberfill cotton cloud elements in our motion capture stage. Our compositing supervisor Sean MacKenzie blended those until we had approximately 60 layers of clouds roiling, moving and expanding."

Harry and Dudley take shelter from the storm in an underpass, where they witness a sudden temperature drop. Yates filmed the scene partly in London's East End and partly on a Leavesden set. ILM replaced a painted cyclorama backdrop with a digital extension of the underpass set, and furnished icy breath and freezing rain effects. "We used a clear spray that crystallized over a 30-second period," stated Alexander. "We sprayed that onto a piece of plexiglass, shot it time-lapse, and digimatte placed those elements onto 3D objects, simulating ice growing on streetlamps and a pool of water."

These events foreshadow the arrival of hideous dementors — demon guardians of Azkaban wizard prison — that attack Dudley and Harry. Nick Dudman's team revamped the existing dementor maquette, based on conceptual designs by Rob Bliss, revealing more of the robed creature's skeletal understructure and doubling vertebrae in its bony tail. ILM translated the design to a digital puppet, adding a virtual noose around the dementor's neck to wrap cloth tighter around its head, exposing skeletal arms, and updated the undulating fabric simulation. "David wanted cloth tendrils to move like an octopus," said Alexander. "When the dementor reached out with his hand, he wanted the cloth to also reach out and grab hold of Harry." ILM controlled cloth tentacle behavior using

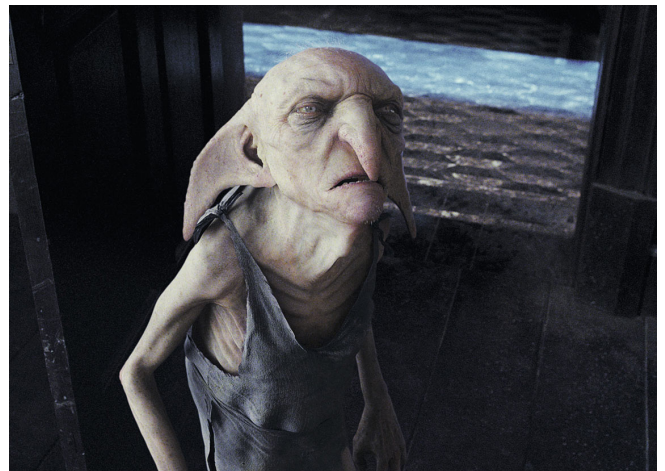
spherical ‘attractors’ to influence specific areas on the cloth. “The dementors previously used a large-scale ‘magnet’ that could influence the whole flow of the cloth. This time, we cut cloth into strips around the bottom of the robes and used 12 attractors to affect the cloth. As we moved the spheres around, the cloth gravitated towards the spheres.”

ILM animation supervisor Steve Rawlins developed previsualizations for the dementor attack on site at Leavesden, guiding on-set interactions. For shots of a dementor pinning Harry against a wall, John Richardson’s team raised Daniel Radcliffe on a levitation rig. As Dudley slips on a frozen puddle and slides toward a second dementor, effects technicians built a sliding rig beneath the elevated set. “We had a track under the set with a little knife blade coming up to a rig that the actor laid on,” said John Richardson. “It was computer-controlled so we could ramp the speed up and down as he slid along.” ILM later wrapped dementor hands around the actors using matchmove geometry to align dementors to the plate.

Harry saves Dudley from the dementor attack, but his unauthorized use of defensive magic lands him in trouble with wizard authorities that communicate via owl delivery. The production filmed a live owl performer delivering wizard mail in a soundstage set at Leavesden. Framestore CFC then created a ‘howler’ letter that springs to life with an angry message from Mafalda Hopkirk (Jessica Hynes) in the Improper Use of Magic Office, animated using high definition reference footage of Hynes’ performance. “We tried to give the howler human characteristics,” remarked Framestore CFC visual effects supervisor Craig Lyn, “but at the same time it had to look like an envelope. We used natural creases and folds in the paper to create the performance, without making it too flesh-like. The wax seal turned into the lips and the envelope flap turned into eyebrows.”

Several wizards arrive to escort Harry to the Ministry of Magic via flying broomsticks. For the wizards’ flight to the city, Tim Burke shot helicopter plates over London. ILM then referenced the footage to generate previz that guided a bluescreen shoot of actors on a broomstick motion base at Leavesden. The early part of the sequence, with wizards descending through the clouds, featured an entirely digital environment with digital doubles of Harry and his escort that had interactive hair and cloth simulations.

Wizards deliver Harry to 12 Grimmauld Place — secret headquarters of the Order of the Phoenix anti-Voldemort alliance — a magically camouflaged suburban home that appears from between adjoining houses in a London street. Production constructed Grimmauld exteriors on the backlot at Leavesden. Performers stood before a greenscreen that covered a part of the set where buildings were designed to move. Rising Sun Pictures then created the magical house appearance by digitally animating building façades. “We wanted the



Members of the Order of the Phoenix, a wizard society pitted against the evil Lord Voldemort, whisk Harry to a secret London refuge inhabited by a crotchety house elf named Kreacher. David Yates filmed Kreacher scenes with voice performer Timothy Bateson delivering lines off-camera, then had Bateson redeliver the lines wearing tracking markers on his face before high definition digital video cameras. Framestore CFC digitally generated Kreacher with wrinkled, greasy skin, broken blood vessels and filthy robes.

transformation to feel solid and heavy,” observed Tim Burke. “We didn’t want the effect to look like an obvious digital squeeze. David used an interesting analogy: he said he wanted it to feel like an old war general dusting down his medals, coming out to fight one more time.”

Rising Sun generated the Grimmauld reveal, simulating a rumble that shook the street as Number 12 emerged from behind a drainpipe. Artists digitally reconstructed the street using a 3D façade of Number 12 and digital projections enhanced by subtle animated interactions. “The muggle houses were CG,” explained RSP visual effects supervisor Kat Szuminska. “We pushed back houses either side of Number 12, added little cloth sims to make curtains jiggle and made a plant shake slightly on a balcony. We rigged parts of the wizard house to move — a window frame pushed down slightly and some bricks in an arch above the window came loose so bits of dust fell out. We wanted it to seem like the building has done this many times before, and it was a bit worse for wear.”



Harry visits the Ministry of Magic, a teeming hub of wizard bureaucracy located beneath the streets of London. Production designer Stuart Craig built the Ministry atrium at Leavesden Studios, taking a design cue from the London Underground, and placed greenscreens beyond the set. The Moving Picture Company then used construction blueprints, lidar scans and tracking data derived from LEDs on set to add digital extensions crafted from photographic surveys. MPC layered shots with reflections, highlights, giant statuary, office towers, crowd replications and flocks of airborne wizard memos.

Inside Number 12, Potter meets classmates Ron Weasley (Rupert Grint) and Hermione Granger (Emma Watson) and his godfather Sirius Black (Gary Oldman) who is attended by a house elf named Kreacher — evil flipside to Dobby, an elf introduced in the second film. “Kreacher was a relatively late addition,” noted Craig Lyn. “J.K. Rowling suggested Kreacher should appear in a few scenes because in the next book there was a big slap-down between Kreacher and Dobby.” Framestore CFC lead creature modeler Alessandro Bonora, CG supervisor Andy Kind and lead texture artist Danny Geurtsen devoted off-duty hours to building a 3D Kreacher head. Nick Dudman’s team created a painted silicone maquette, then Framestore CFC refined the elf’s final look. “Kreacher was wrinkled, gray, with liver spots, not much hair and a crooked nose. Whereas Dobby had been a bit cute, Kreacher was a nasty, mean old man.”

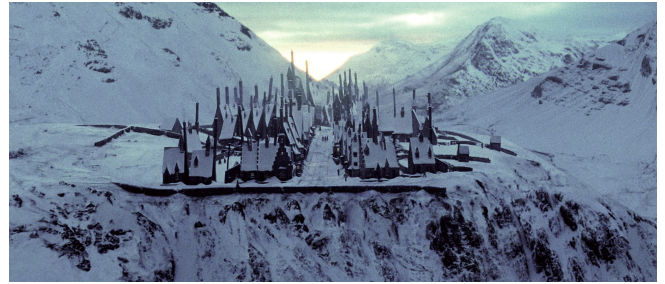
Actor Timothy Bateson delivered Kreacher’s lines from off-camera during filming as John Richardson’s team supplied subtle physical interactions. Bateson then redelivered Kreacher’s lines wearing tracking markers on his face before six high-definition digital video cameras. Framestore CFC animation supervisor Max Solomon used the reference to develop keyframe animation while CG supervisor Ben White oversaw Kreacher digital look development. “David Yates sent us a book of nude old people as reference,” recalled Craig Lyn. “We emulated how their skin had a dry, parchment-like feel but at the same time had a greasy look to the nose and ears. We created caustics in Kreacher’s eyes and broken blood vessels underneath his skin with subsurface scattering.” Senior technical director Rob Allman worked with rigging supervisor Felix Balbas to rig Kreacher with stringy interactive neck tendons that connected with jaw movements and muscles in the face, while animated displacement maps created wrinkles on his forehead and around his eyes. The elf was then dressed in a grimy sackcloth robe animated with Syflex cloth simulation.

Grimmauld Place contains magical miscellany including Nymphadora Tonks, a Phoenix order member who exhibits an ability to change her appearance at will — achieved by Framestore CFC morphs — and a tiny broomstick-riding Santa Christmas decoration, which *Baseblack* technical director Pierson Lippard modeled to resemble a 1960's tin toy with chipped paint and a reflective metallic surface.

Ron Weasley's twin brothers spy on an off-limits Grimmauld wizard conversation using a 'listening ear' eavesdropping device resembling a severed human ear on an umbilical cord. Nick Dudman's team supplied a prosthetic ear for performers to dangle over a balcony as a cat swiped at it with its paw. Cinesite then imbued the prop with an animated personality. "The listening ear was like a little commando lowering on a rope," related Cinesite visual effects supervisor Michael Illingworth. "Our lead animator, Ryan Cronin, made it bend as if it were reacting to noises behind the door. Then, when the ear 'saw' the cat, it jumped back, quite startled. David Yates liked the interplay between the cat and the prosthetic, so we retained that movement, put our CG ear over the top and added extra wiggle, with subsurface scattering to show translucency and veins below the surface."

Harry Potter pays a visit to the Ministry of Magic via a visitor's entrance disguised as a British red telephone box. Yates filmed Harry and his escort, Mr. Weasley, entering a dummy phone box on location in Central London. Physical effects then rigged a mechanical descending rig on a bluescreen stage at Leavesden. "We built a telephone box within a telephone box that went up and down," said John Richardson. "Once Harry and Mr. Weasley entered the phone box, the exterior stayed still and the interior descended, so we saw all the glazing bars in the telephone box move against one another. As they disappeared, another telephone box interior took their place." Cinesite 2D artist Alex Smith composited the sinking telephone box into plates of a London street. Richardson's team continued Harry's descent into the Ministry of Magic with an elevator interior on a computer-controlled winch system, and employed a mechanical rig to simulate another wizard elevator that unexpectedly zoomed backward 40 feet in a horizontal direction.

Stuart Craig built the atrium of the Ministry as a 200-foot-long set at Leavesden. MPC made the voluminous chamber even larger with digital extensions. "We had greenscreens at either end of the set that allowed us to extend it three or four times," related Tim Burke. "Stuart had built a row of fireplaces where wizards were coming and going through the 'floo powder' network. We extended that



Back at Hogwarts during the winter term, Harry and his classmates visit Hogsmeade. The production built part of the village at Leavesden. Cinesite miniature effects supervisor José Granell then oversaw construction of a full miniature village detailed with shop fronts, stonework, roof tiles and chimneys. Double Negative tracked footage of the village, filmed with a motion control camera descending over the miniature, into a helicopter plate of Scottish landscape, and blended digital environment enhancements and animated inhabitants.



in a gentle curve, so we couldn't see how far they went. In the other direction, we had a large fountain, balustrade and a huge tower of stacked circular offices that went up as far as you could see."

MPC used LED tracking markers around the set to help integrate extensions, and then built digital set pieces from on-set surveys. "The art department gave us blueprints of the set," related MPC visual effects supervisor Greg Butler. "We worked those into designs using lidar scans and our own photo survey of the set. We shot 'mid-dynamic range' surveys — three exposures per shot — which gave us just enough information to re-light textures for nighttime scenes. We digitally painted out reflections to create a color map of the environment, and then projected photos back onto the geometry. That allowed us to avoid doing UV layouts for all the tile surfaces, putting more shading effort into reflections and highlights." 3D extensions included the chamber ceiling, a giant golden wizard statue and office towers. "The offices on set went up two levels high. For shots where we saw just one office higher, we did a 2D repeat. Wherever we saw more than that, we used CG offices with projected photos and CG lighting using our hybrid approach of projection, CG shading and lighting on top."

Production filmed wizard crowds using repeat passes and bluescreen elements, which MPC tracked and composited into plates. MPC animation supervisor Ferran Domenech oversaw behavior of flocks of paper airplanes representing wizard memos, color-coded with red indicating urgent missives, using particle animation to guide large shoals of memos and keyframe animation for closeups.

The Ministry of Magic allows Harry to return to Hogwarts, despite his insecurities about Voldemort's looming presence. Harry has a vision of the Dark Lord as he prepares to board the Hogwarts Express at King's Cross Station. Yates filmed the scene on location with a body double standing in for Ralph Fiennes, revealed through a cloud of steam venting from the Hogwarts Express. "Scheduling made it impossible to have Ralph there on the day," said Tim Burke, "so we shot him later on bluescreen. Then MPC digitally replaced the double's head with Ralph's. The last closeup was a complete bluescreen replacement, using the same digital/prosthetic makeup developed in the previous film. Voldemort's facial configuration effect worked so well, it was featured in approximately 60 shots."

Hogwarts students learn of a prison break from Azkaban in a Daily Prophet newspaper montage created at Cinesite and ILM. The production shot Helena Bonham Carter – as Voldemort acolyte Bellatrix Lestrange – on a partial set representing a blown-open penitentiary wall. ILM digitally extended the prison tower, surrounded by CG ocean and swirling dementors, and then generated a pullback. Cinesite nested the element into animated Daily Prophet pages, swooping in and out of live-action footage depicting related news stories, then tracked the page into a prop newspaper.



Harry and Luna Lovegood (Evanna Lynch) encounter a herd of thestrals, skeletal winged equines visible only to those who have witnessed and accepted death. ILM based the CG animals on a full-scale maquette created by the Nick Dudman team. The thestral's translucent anatomy, with skeletal structures visible through thin layers of skin and muscle, required simultaneous development in ILM's animation and look-development teams, which rendered walk cycles and animation tests directly into forest environments to help define the creature's majestic stature.

Voldemort's face — completely hairless, with reptilian slits for a nose — incorporated prosthetics that Nick Dudman's team had perfected for the fourth film. Fiennes shaved his head, allowing application of tattoo transfer veins, with prosthetics covering his eyebrows. MPC revised facial tracking markers to facilitate easier digital paint-out, integrated a new cyberscan of Fiennes' head to improve lineup with the digital facial prosthetic, and implemented a revised workflow for lighting and compositing that allowed Voldemort to be integrated into a variety of environments.

Harry's subsequent Voldemort nightmares incorporated flashes of imagery that Tim Burke and previsualization editor Simon Burchell manipulated in After Effects. MPC generated effects for a nightmare in which Harry sees Mr. Weasley menaced by Voldemort's animal form — a giant snake, 'Nagini' — seen in a reflection. "We shot the scene against greenscreen, tracking toward Mr. Weasley from Nagini's point of view," explained Burke. "The camera moved to the right and revealed the snake's reflection in a tiled wall, which MPC added in CG. We continued tracking forward toward Mr. Weasley, pushed the camera in and out as far as possible, and then overwrote that with a digital move, violently snapping in and out, as if the camera was attacking."

Voldemort was also glimpsed in one of several Hogwarts transition shots created at Double Negative, his face appearing in a snow flurry outside the Gryffindor common room. "There was no glass in the common room window," observed Double Negative visual effects supervisor Paul Franklin. "As the camera pushed forward, we added a CG window so the camera appeared to magically slip outside into a rainstorm. The rain was a combination of practical elements and CG rain. That appeared to freeze and transitioned to a particle animation snowstorm. We used MPC's Voldemort head model as a dynamics target to magnetically attract snowflakes, which momentarily held together and blew apart as the camera passed through. We extended snowfields in the aerial plate and synchronized the camera move with the move on the Hogsmeade miniature. Then Adam Paschke, our senior compositor, and his team added plumes of chimney smoke, lights in windows and 15 keyframe people walking in the streets."

After disembarking the Hogwarts Express, students board carriages tethered to skeletal winged thestrals that, initially, are visible only to Harry. ILM generated thestrals using a full-scale maquette that Nick Dudman's team sculpted from a Rob Bliss conceptual design. Sculptors Kate Hill and Julian Murray led the thestral sculpt, producing wing and body configurations separately, while Bliss used images of the work in progress to generate Photoshop mockups.

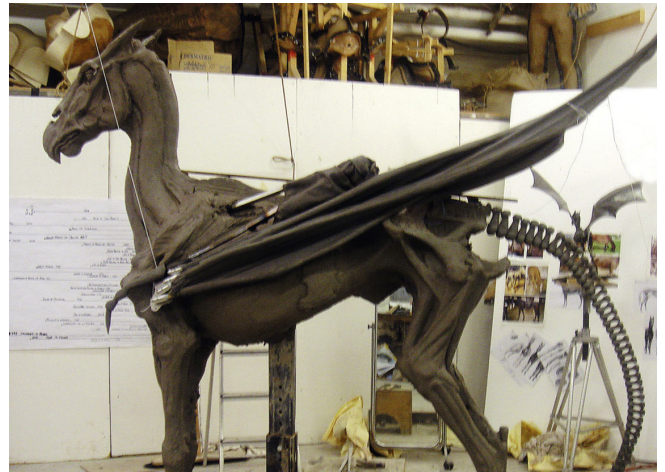
Once the sculpture was complete, Dudman's team cast a rigid gray-painted thestral for cyberscan and a painted version for color studies. "There was some question if we needed to do a paint job," noted Dudman. "Thestrals were supposed to be jet black, but if we had just painted them black they would not have looked real. We decided to produce a painted thestral that was paler than the finished thestral, showing patterning, veins and shading. The theory was that Stuart Craig could art-direct the subtleties, and then ILM could make the creature as dark as they liked."

ILM character rigging supervisor Eric Wong oversaw creation of the digital thestral and simulation controls, which involved detailed interactive bone and muscle structures and skin interactions. "We did an additional simulation on top of bones and muscles," stated Tim Alexander. "We simulated a layer of skin that had a lot of slide to it; so as the thestral moved, its skin slid over its ribs. We used

elephant textures to create wrinkles in the surface, then made it look glossy using subsurface scattering and indirect radiosity-style lighting.”

The ILM animation team developed thestral walk cycles, rendering animation tests directly into forest environments to help define the creature’s mood and stature. “The director wanted the thestral to be quite elegant and majestic,” said Steve Rawlins. “That was tricky because we were essentially pulling a skeleton around with all the anatomy exposed, so it became very important to get all the musculature working. We built a library of shapes that allowed muscles to fire and tense as the legs picked up and set back down. What really helped sell the believability was the way the scapula slid up and down and, when the thestral’s foot hit the ground, all the weight fell into that area. That gave the creature a great sense of mass and helped drive the skin simulations.”

Harry later discovers that he shares his ability to see thestrals with another student, Luna Lovegood (Evanna Lynch), who introduces him to a herd of the creatures in the forest. Nick Dudman’s team supplied a painted stand-in baby thestral, the size of a greyhound, to assist with actor eye-lines. ILM digital model supervisor Ken Bryan used scans of the maquette to develop a baby thestral that fed from Luna’s hand. “David Yates wanted audiences to see that thestrals were not exhumed living-dead creatures,” observed Rawlins. “He wanted to show that they bred and had young, so he came up with this wildlife documentary scene with the youngster.”



A small-scale maquette was first created to establish the thestral’s anatomy and size relationships between its wings and body. A team of Dudman sculptors then sculpted full-scale separate body and wing sections, while conceptual designer Rob Bliss photographed the work in progress and generated digital photographic mockups. Dudman’s crew then molded and cast a rigid gray-painted thestral for cyberscanning, and produced a painted version to illustrate thestral livery.

To depict events unfurling in the wizard world beyond Hogwarts, Cinesite created a series of montage effects featuring the Daily Prophet newspaper whose photographs come to life. For a Daily Prophet scene depicting Voldemort acolyte Bellatrix Lestrange (Helena Bonham Carter) escaping Azkaban prison, the production shot an element of Lestrange emerging from a blown-open wall. ILM then generated a pullback from the wizard penitentiary, a monolithic stone tower rendered in 3D, surrounded by a digitally generated ocean storm and tiny swirling dementors. Cinesite nested the pullback into a newspaper with headlines and animated turning pages, revealing a wizard press conference — a live-action camera move on the Ministry of Magic set — and a moving mug shot of Lestrange, before pulling back out into a scene of Neville Longbottom — filmed with the actor reading a newspaper prop with a greenscreen panel representing the animated printed image.

Harry has conflicts with Hogwarts' new Defense Against the Dark Arts teacher, Professor Umbridge, who imposes sanctions on the student body and sentences Harry to repeated detentions, handing him a magic quill that slices words into the back of his hand as he writes. Radcliffe performed the scene wearing tracking markers on his hand for closeups, and mimed writing on blank paper with an inkless pen. Double Negative used samples of Radcliffe's cursive to animate handwriting appearing in Potter's blood. Senior matchmover Elisenda Faustino tracked a NURBS patch onto Radcliffe's moving hand, onto which lead 3D artist Becky Graham projected animated reveals of Radcliffe's writing, synchronized with writing on the paper. Multiple iterations of bruising and contusions achieved a wounded look without jeopardizing the film's MPAA rating.

Harry rebels against Umbridge by gathering a group of students in a secret chamber to practice defensive magic as 'Dumbledore's Army.' Yates shot training sessions using mechanical levitation rigs to float the young performers in midair, and a 'Death Eater dummy' prop resembling a roving mechanical man-size target on a monocycle wheel. Double Negative created a CG version of the Death Eater for shots of the prop whizzing about the room as young wizards bombard it with spells, shrinking it to nine inches tall and eventually obliterating it.

Double Negative also created a series of 'patronuses' — ethereal animal talismans personal to each wizard. "It was important to Jo Rowling that we attributed appropriate patronuses to each student," noted Tim Burke. "At one point we'd proposed using a bird as a patronus for Ginny Weasley, but Jo was insistent that she have a horse, which was slightly harder to animate because of its scale in the set. It turned out to be one of the film's most beautiful effects." Patronuses included an otter for Hermione, a dog for Ron and, for Luna, a hare that bounded about the room defying gravity. Double Negative animated the patronuses in Maya. CG supervisor Justin Martin exported the animated creatures to Houdini to create rippling trails in their wakes, and then converted elements back to Maya where effects animator Markus Drayss applied



Although large-scale animatronics took a back seat to digital creations, the Dudman team produced maquettes for every creature seen on screen, establishing character designs and lighting reference. Key moldmaker Jamie Iovino examines a partially molded full-scale maquette of the giant Grawp, a digitally animated character generated at Double Negative.



The moldmaking team attends to a multi-part mold used to create a full-scale maquette for a noble race of centaurs, digital characters that Framestore CFC animated in profusion for scenes in the Forbidden Forest.

RenderMan shaders in Double Negative's lighting interface, Rex. Lead compositor Tristan Myles blended elements in Shake with additional glow, halos and grading, and used rotoscoping to integrate patronuses into their environment.

Harry's training includes 'occlumency' lessons, during which Professor Snape teaches him how to close his mind to Voldemort's invasion of his memories. Tim Burke and Simon Burchell designed the sequence using 'memory' footage from the first three *Harry Potter* films and bluescreen elements of Alan Rickman. Machine and Framestore CFC then composited Snape into shots — Rickman at one point inserted behind the reflection of 11-year-old Daniel Radcliffe standing before the Mirror of Erised from the first film — and Burchell interwove memory fragments in After Effects.

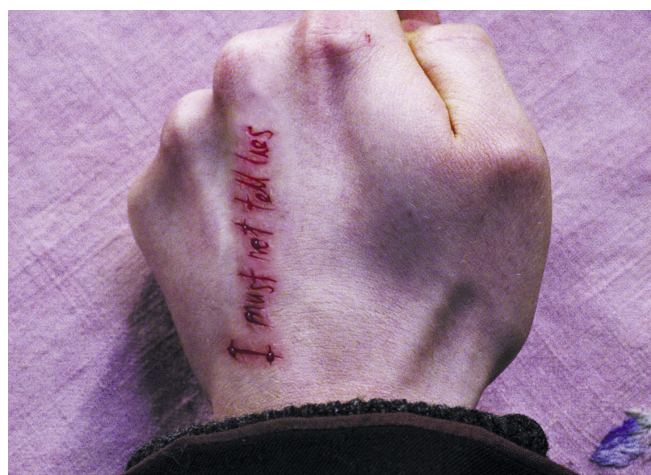
Harry strikes back at Snape by delving into the professor's memories, revealing Snape as a young man humiliated by fellow Hogwarts students, including a young Sirius Black and Harry's youthful father. Yates shot Snape's memory at a riverbank in Oxfordshire. John Richardson's team used a pole-arm levitation rig, filmed against bluescreen, to invert and shake young Snape. Cinesite added Scottish scenic material and a miniature element of Hogwarts to location plates.

Young actors resembling their adult counterparts wore subtle prosthetic enhancements for the scene. "My key prosthetic makeup artist Mark Coulier and prosthetic supervisor Paul Spateri spent a long time playing with nose tips, ear tips, forehead bits and lips to sell the characters," said Nick Dudman. "We used a mixture of gelatin and Platgel silicone appliances. For young Snape, we broadened and lengthened the actor's nose, gave him dentures and black contact lenses. Hair designer Colin Jamison gave him a wig like Snape's, so he was easily recognizable. The hardest one was young Sirius because, as a younger version of the character, we were not able to give him Sirius' distinctive facial hair. With Gary Oldman, the character was all in the eyes."

Umbridge unmasks Harry's subversive activities, causing Hogwarts' headmaster Albus Dumbledore (Michael Gambon) to resign, vanishing in a flurry of magical fire with his pet phoenix, Fawkes. Framestore CFC revisited the CG Fawkes created for the second Potter film and reconstructed the bird from scratch. Lead compositor Ben Aickin then wrapped Fawkes and Dumbledore in fire, meshing pyrotechnic elements to the shape of Dumbledore's body.

Ron Weasley's brothers infuriate Umbridge by taking their leave of Hogwarts on flying broomsticks after unleashing an indoor fireworks display. MPC generated previsualization for the sequence that guided live lighting cues and animated pyrotechnic events. The sequence included bluescreen plates of the Weasleys on motion base broomsticks and swooping camera angles filmed from John Richardson's four-winch flying system to capture points of view chasing Umbridge through the fireworks.

The physical effects team also rigged an in-camera effect to simulate the fireworks dislodging 90 glass-framed Ministry of Magic proclamations that



A painful inscription appears on the back of Harry's hand as he writes 'lines' in detention overseen by the sadistic Professor Umbridge (Imelda Staunton). Daniel Radcliffe performed the scene wearing tracking markers on the back

explode from a wall, and staged a library of firework elements filmed at 48 and 96 frames per second.

MPC 2D supervisor Charlie Henley layered practical pyrotechnics with digital elements. For a climactic pyrotechnic event, MPC CG supervisor Clwyd Edwards created a giant Chinese dragon made of red and gold sparkles. “We developed the fire dragon

first as a 2D concept, then moved to 3D,” said Greg Butler. “Our animation supervisor animated the dragon and then our effects artist generated all particles off that geometry using Maya particles and in-house tools. We layered in additional 2D smoke elements on top of that, along with 3D sprite-based smoke. Every once in a while, we threw in live pyro elements, taking cues from actors in the plate until we built up the effect of the dragon chasing Umbridge.”

of his hand, and mimed writing on blank paper with an inkless pen. Double Negative used samples of Radcliffe’s cursive to animate handwriting appearing in Potter’s blood. Artists then projected animated reveals of the inscription onto the back of the actor’s hand, with subtle reddening, bruising and specular highlights simulating wetness and depth inside the wound.



Harry gathers students to secretly practice defensive magic, manifesting patronuses – ethereal animal talismans personal to each wizard. Author J.K. Rowling suggested patronuses appropriate to particular students, including a hare for Luna Lovegood. Double Negative animated 3D creatures with rippling wakes, lighting effects and interactive elements.

Harry and Hermione try to escape Umbridge's attentions with the assistance of creatures in the Forbidden Forest, including Grawp, a 16-foot-tall giant — half-brother of Hogwarts' gamekeeper Rubeus Hagrid (Robbie Coltrane). The digital character was an early focus of attention for the production. "We scheduled Grawp as one of our first scenes to help walk David through the process of creating complex CG characters," said Tim Burke. "We started with maquettes that Nick Dudman's team built for us." Grawp maquettes included a full-scale head and shoulders of the giant, and a smaller-scale body that stood about five feet tall. Concept designer Adam Brockbank and sculptor Kate Hill studied photographs of a youthful Robbie Coltrane as a guide to capturing Grawp's familial resemblance. The full-scale sculpture, cast in silicone, painted and detailed with realistically-scaled hair, was then hoisted above the forest set for lighting and actor reference.

For more mobile Grawp interactions, Dudman's team constructed an adjustable mechanical rig for puppeteer William Todd-Jones, who wore a blue suit beneath a shoulder-mounted rig with jointed arms and a 16-foot-tall extendable pole with a vacuformed Grawp head on top. "It was like a bunraku puppet," observed Dudman. "Todd could lean forward to tilt the head and had rods going from his hands up to Grawp's wrists. We kept it lightweight to help with leverage, but Todd was used to doing big dramatic stuff inside full-body puppets. He moved about the set, giving the kids their eye-lines."

Grawp's performance on set was guided by previsualizations developed through Double Negative's complex animation pipeline. Grawp facial studies began with an Image Metrics motion capture process that keyed off Tony Maudsley's facial musculature employing Double Negative's implementation of Paul Ekman's and Wallace Friesen's 'Facial Action Coding System,' which decomposed human expressions into 28 base expressions. Facial muscle simulations and full-body motion capture served as reference for character lead Colin McEvoy and animation supervisor Eamonn Butler, who produced a 100-percent keyframed Maya animation.

Double Negative transported previz to set via an imaging system devised in collaboration with Lester Dunton of Joe Dunton Cameras and Olaf Wendt of United Image Systems. "We captured real-time action from a motion-encoded SuperTechno30 rig," Paul Franklin explained. "JDC encoded the rig. We took the output from their encoders, fed it into MotionBuilder and applied practical camera motion to a virtual camera inside a 3D replica of the Forbidden Forest set. We manually cued our previz of Grawp with a dial box and sent the output to the vision mixer to composite it in real-time



Umbridge flees a giant Chinese dragon that swoops through Hogwarts' Great Hall in a magical fireworks display unleashed by the Weasley twins. MPC created fireworks effects, referencing practical pyrotechnics, and generated the fiery dragon by emitting particles from an animated 3D object layered with lighting effects, pyrotechnics and smoke.

with the feed from the video tap.” The vision mixer fed the image of the animated character, composited with the camera view, to video goggles worn by William Todd-Jones who viewed the image in one eye as a heads-up display and moved in time with the animation. “The previz showed the puppeteer where to move. Actors could react to him and the director could watch the whole thing composited in real time on the video monitor.”

To build the final animated Grawp, Double Negative creature supervisor Ged Wright used Plowman Craven Associates and Gentle Giant cyberscans of maquettes. CG supervisor Richard Clarke organized life reference of a large hairless man, who shaved his body for a texture photo session. “Grawp was on the edge of puberty,” noted Paul Franklin, “so we gave him a little ‘bum fluff’ on his face and chest and used a lot of subsurface scattering in his skin shader. He had a rather brutal hair cut because Hagrid has tried to cut it for him, so we gave him a choppy hair groom in Joe Alter’s Shave and a Haircut plug-in for Maya with a lot of extra filters, grooming tools and a hair shader inside RenderMan. His hair was supposed to be dirty and matted, because he’s a grubby little boy always playing in the bushes.”



Members of the student resistance flee the Hall of Prophecies as Lord Voldemort’s Death Eaters attack in the lower levels of the Ministry of Magic. Stuart Craig envisaged the hall as a vast repository of glowing glass orbs, which Double Negative generated as a virtual environment. Director of photography Slawomir Idziak photographed actors against greenscreen, illuminated with five stages of interactive lighting. Double Negative then generated rows of glass shelves, stacked with glowing spheres that became progressively brighter until the Death Eater attack caused their collapse.

Grawp first displays his strength by picking up Hermione. John Richardson’s team used the programmable pole-arm rig to lift Emma Watson on a hidden saddle, with bluescreen forms representing Grawp’s fingers. For his later confrontation with Umbridge, Double Negative animated the character lifting Umbridge by the scruff of her neck, disdainfully holding the woman between his thumb and forefinger. Artists exported Grawp’s action to a motion control pole arm rig, where Imelda Staunton dangled, twisting and reacting with indignation. Compositing supervisor Jelena Stojanovic’s team then painted out effects rigging and blended Umbridge into Grawp’s grip.

The forest confrontation brings Umbridge face to face with a centaur herd. David Yates shot the scene with blue-suited performers playing centaur leaders Magorian and Bane. Framestore CFC generated the creatures, and 20 other centaurs, as digital characters given a complete makeover since the last appearance of a centaur in *Harry Potter and the Sorcerer’s Stone*. “Most centaurs seen in movies have had the back half of a horse with the top half of a man stuck on,” Nick Dudman observed. “Adam Brockbank came up with a lovely idea to make the centaurs more of a complete animal, where the top half of the creature was human but completely covered with the pelt of a thoroughbred racehorse.”

Dudman's team tested the centaur concept by making urethane castings of a maquette treated with flocking and hair-punching techniques to simulate an equine pelt. The creature design team made allowances for revisions using an adjustable sculpture armature. "My engineers came up with an armature with sliders for width and height adjustments," said Dudman. "We knew roughly where all the bolts were, so when we had to take out a four-inch slice, we did keyhole surgery, removed the bolts, used cheese-wire to slice through the chicken wire, plaster bandage and clay, pushed the back away, and adjusted the section as needed. We then slid back the rear and re-sculpted that section." Framestore CFC generated a digital model based on scans of the maquette and rigged an underlying muscle system, dynamic skin, Maya fur dynamics, Syflex manes and tails, and a full facial animation rig capable of lip-sync.

For a sequence in which Umbridge binds Bane with a magical rope, causing the centaur to tumble down a hill, actor Jason Piper performed the scene on the forest set, interacting with Emma Watson as Hermione rushes to the centaur's aid. Max Solomon's animation team then used the upper half of Piper's performance to position Watson's hands on the centaur's writhing body. "We had to have a lot of muscle groups for the interactions to work," Craig Lyn said. "Felix Balbas handled the rigging and made muscles jiggle. CG effects supervisor Mark Hodgkins and lead rigger David Short made all the ribs, musculature and even the veins slide about underneath the skin. Then we had to create facial performances for every frame. Our animation team keyframe-animated every centaur."

Framestore CFC compositing supervisor Alex Payman integrated centaurs into the forest set using elements derived from a physical effects shoot of green hoof forms interacting with the ground. As centaurs and Grawp retaliate and turn on Umbridge — filmed with Imelda Staunton, again, hoisted on a mechanical pole-arm rig — compositors applied 2D distortion to manipulate the Umbridge element.

Having rid themselves of Umbridge, Harry and Hermione lead members of their alliance on a thestral flight to London, responding to Harry's premonition that Sirius is in jeopardy. ILM generated airborne thestrals by combining keyframe creatures with motion control elements of riders, the Hogwarts miniature and scenic aerial plates. "Tim first shot helicopter plates in Scotland," explained Tim Alexander. "We did matchmoves back at ILM and used that to work out thestral animation. We exported that data to Leavesden for Tim to film actors on the M-rig. Then we composited those bluescreen elements into aerial plates."



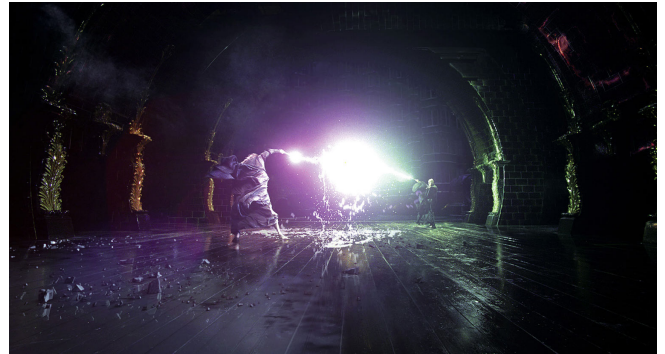
After escaping the Hall of Prophecies, Harry and his friends arrive at the Veil Room, a mysterious chamber facing a stone archway hung with a giant diaphanous veil. The production filmed Veil Room scenes in a small set at Leavesden that contained a partial arch. Double Negative extended the set and generated a veil in the arch that represented a supernatural barrier with the afterlife. Double Negative filmed translucent parachute silk at high frame rates and then emulated its wafting motion using cloth simulations, distortions and chromatic aberrations.

ILM gave the thestrals a flying gait, tucking the creatures' forelegs, extending hind legs and adding interactive motions timed with wing flaps. Wing beats synchronized with a practical lighting rig in the M-rig shoot. "As the thestral wings came up, they blocked low-raking sunlight backlighting Harry," said Steve Rawlins. "They had a light on the M-Rig shoot going on and off in time to wing beats in our previz. It created a natural lighting effect right there in the plate — the sunlight went away and then came back as the wing beat down — and it lined up perfectly." The thestrals descend through a lightning storm — generated by layering fiberfill cloud elements — then swoop down over nighttime London, composited into helicopter plates shot above Canary Wharf.

Harry and his team infiltrate the lower levels of the Ministry of Magic and enter the Hall of Prophecies — a vast repository of wizard memories contained in glass orbs. The environment took shape early in preproduction as a clear contender for digital enhancement. "Stuart Craig came up with a mad concept of an infinite room with glass shelves containing glowing prophecy orbs stretching out in every direction," stated Tim Burke. "We looked into creating 35,000 practical prophecy spheres, but that would have only filled a small area of the stage. We all agreed the only way to make this happen was to do it digitally."

To guide actors and crew in the virtual environment, director of photography Slawomir Idziak developed an interactive lighting plan — beginning dark and mysterious, as Harry and his friends arrive to search for Sirius, then becoming brighter as Voldemort's Death Eaters arrive, causing the prophecies to glow until the room erupts with smoke and light as a fight breaks out. "We tested and developed five stages of lighting," noted Burke. "Slawomir plotted where each of the lighting stages occurred. Stuart Craig built a walkway and green-painted wire-frame shelves, then we greened-up the floor and walls and David filmed the actors going through our lighting environments."

For shots where Harry discovers a prophecy that pertains to his own destiny, John Richardson's team created portable practical orbs, some made out of acrylic, with closeup versions made out of glass and illuminated from within. Wide shots featuring hundreds of thousands of the glowing prophecies incorporated a digital environment generated at Double Negative. "The geometry in each shot in the Hall of Prophecies was as complex as a city," remarked Paul Franklin. "We had about 170 shots in the whole sequence, so it was a mammoth undertaking. The art department made designs for 50 prophecy stands. We reproduced those digitally with spheres of various size. Each prophecy contained glowing undulating plasma, which reacted to movement. As action kicked off, they became more agitated until they were glowing brilliantly. Lead technical director Chris Magnall built a complicated procedural shader in RenderMan to create a swirling three-dimensional



Dumbledore (Michael Gambon) and Lord Voldemort (Ralph Fiennes) engage in a fierce wizard duel. MPC generated set extensions, Voldemort digital facial prosthetics and wand effects for the sequence. Wand blasts of fiery ropes and splattering lava-like material were designed to resemble wand effects seen at the climax of the previous Potter film. Slawomir Idziak lit actors on set with intense directional lighting. MPC digitally reexposed the scene to enhance blinding wand effects, and incorporated simulations, cached from the previous film, to animate chunks of plasma raining onto the floor.

liquid cloud that was alive and churning. We used a RenderMan feature called ‘brick mapping’ to build background shelves, which was much more efficient than using full-blown geometry.”

Death Eaters attack, causing shelves to topple and prophecies to shatter. Double Negative used its in-house dynamics engine, Dynamite, integrated with its city-building asset management system to wrangle rigid body simulations of crashing shelves and prophecies. 3D lead Dave Vickery and technical director Trina Roy based simulations on the burning of Atlanta in *Gone With the Wind* — giant structures retaining their integrity but distorting as they collapsed.

Harry’s prophecy contains the vaporous image of Divination Professor Sybill Trelawney (Emma Thompson) who intones a mysterious hint at Harry’s destiny. Double Negative used facial capture of Thompson and a cyberscan of the actress’ head to generate Trelawney’s fragmented prophecy. Compositing supervisor Jolene McCaffrey oversaw creation of the Trelawney sphere containing a 3D model of the actress’ head, rigged for facial animation, and erratically juxtaposed expressions. “It was an organic cubist approach to making a face,” remarked Paul Franklin. “Dave Vickery supplied 3D elements, then 2D artist Debbi Coleman brought the imagery together. Then, of course, we had to track the whole thing into Daniel’s hand.”

Harry and friends escape the Hall of Prophecies, jumping through a doorway and landing in an amphitheater facing a giant diaphanous veil. Yates filmed the Veil Room sequence in a partial, but expansive set at Leavesden that included a 13-foot-high, barrel-shaped arena backed by a painted cyclorama surrounding a central island and a partial arch. Double Negative extended the set with rows of seats resembling a Roman coliseum, and added a supernatural veil suspended in the arch. “The veil represented the border between this world and the next,” Franklin explained. “It was so subtle it could only be seen if the viewer looked at it directly.” As reference for the veil, Stuart Craig’s team supplied translucent parachute silk samples, which Double Negative photographed at high frame rates while air movers buffeted the fabric. “We built the veil with Syflex cloth simulations in Maya and custom shaders. We added distortions and



Voldemort conjures a giant fire serpent during the battle. John Richardson’s team produced practical fire elements on set. MPC then created the fire serpent as a 3D animated character, and worked in collaboration with Scanline to apply digital fire using Scanline’s physics simulation engine, Flowline.



Dumbledore counters by imprisoning Voldemort in a blob of water. Richardson levitated Ralph Fiennes on a spinning pole-arm rig. MPC then replaced the actor’s facial features with Voldemort’s snake-like flattened nose, and used Flowline water simulations and practical water effects to imprison the Dark Lord.

subtle chromatic aberrations to create a sense that the veil was bending light and changing the nature of reality when Harry looked through it.”

Death Eaters descend on the arena and fighting reaches fever pitch. John Richardson’s team supplied practical interactive wand effects using light emitting diodes in wand tips that actors could trigger. More powerful wand blasts used clusters of 40 to 50 LEDs, triggered from off-camera using radio control. Double Negative digitally enhanced the effects. “We did a lot of practical augmentation on top of the practical wand effects,” noted Tim Burke. “We added dust and smoke and bits of fire and debris. We really turned it into a gritty *Saving Private Ryan* number.”

The conflict ends with the death of Sirius Black who passes through the veil, to Harry’s great distress. To shoot the scene, John Richardson’s team suspended Gary Oldman in a levitation rig that allowed the actor to fall backwards and float through the arch. Double Negative then generated a series of layered cloth animations to wrap around Oldman. “The veil reached out to shroud him,” stated Franklin. “We added distortion and displacement, compositing in Shake, and warped the veil to match Gary’s shape. We then dissolved away definition, sucked the color from his face, added cataracts to his eyes and carried him through the veil.”

The film’s finale continues in the deserted Ministry of Magic atrium as Dumbledore steps in to engage Voldemort in a ferocious wizard duel. “David wanted to show that these were the two most powerful wizards in the world,” commented Tim Burke, “and so the fight had to be spectacular. He wanted massive effects, but he wanted it to be over in seconds, leaving audiences wanting more.” The duel began with an effect that picked up stylistically from the end of the previous film. “We used Harry’s and Voldemort’s wand duel in the graveyard from Goblet of Fire as the starting point for the Voldemort and Dumbledore fight. Greg Butler and his conceptual team at MPC ramped up from there as the wizards use the environment to attack each other. David wanted the duel to be elemental.”

Fiery ropes that leap from Dumbledore’s and Voldemort’s wands required adaptation to retrofit effects generated for Goblet of Fire. “We reused a few 2D and 3D elements,” observed Greg Butler. “But whereas in the last film there had been electrical bolts meeting in a plasma ball that shifted back and forth, David wanted more of a rushing force.” Slawomir Idziak illuminated the actors on set with intense directional lights. MPC digitally reexposed the scene, darkening backgrounds to simulate the camera aperture adjusting to accommodate blinding wand effects. Wand streams incorporated Realflow ‘blobby’ simulations, cached from the previous film, to animate chunks of plasma sputtering from wands and decaying on the atrium floor.



Voldemort shatters Ministry of Magic office windows with a blast of energy, causing glass shards to rain down on the atrium. John Richardson’s team built hundreds of breakaway windows for the scene, and shattered panes above the set using an array of air mortars. Chunks of silicone dummy glass were used for shots of shards raining on Voldemort. MPC extended exploding ministry offices with dynamic simulations of shattering glass, matching practical bursting windows to enhance initial explosions and then continuing into full digital simulations using MPC’s rigid body dynamics system.

Voldemort assails Dumbledore's defenses by conjuring a giant serpent made of fire. John Richardson's team generated a variety of practical fire elements using flamethrowers and smaller-scale pyrotechnic burns. To create the fire serpent, which rears up and attacks Dumbledore, MPC generated a 3D animated snake. Lead technical director Evangelos Christopoulos then applied digital fire, capitalizing on MPC's ongoing collaboration with German visual effects studio Scanline and its dexterous physics simulation engine, Flowline. "We generated 'fuel' off the serpent geometry," explained Butler. "We then supplied 'oxygen' to that fuel to ignite it, and it burned as long as there was fuel. David wanted the fire to appear dangerous enough to kill Dumbledore; but it was a magical fire, so we kept it clean, without a lot of smoke."

Scanline enhanced Flowline's simulation engine to enable MPC to create sufficient detail to render the 60-foot-tall fire serpent. "We introduced controls to create different looks," said Scanline visual effects supervisor Stephan Trojansky. "After the main work of the simulation was done, MPC adapted the shape of the flames. Evangelos Christopoulos added 'weight' to flame motion, so flames did not appear to flicker like little candle flames in a wind. He also rendered the full volume of the fire, not just the outside 'shell' of the flames. Those were key factors in creating illusions of scale."

MPC 2D lead Stuart Lashley blended practical flamethrower elements into composites as Dumbledore repels the fire serpent, throwing fire back at Voldemort. Dumbledore counters fire with water, levitating liquid from the atrium fountain and imprisoning Voldemort inside a hovering fluid mass. Yates filmed Voldemort suspended in midair using a physical effects rig to support Fiennes. John Richardson's team built a saddle-type body mold mounted on a pole arm rig and spun Fiennes in a controlled manner, cameras running at high speed to simulate floating motions.

Richardson's team created practical water reference for a bluescreen shoot with custom-made six-foot-diameter plexiglass balls mounted on plexiglass rods with water sprayed inside and outside, and large dump-tank effects for use when Voldemort explodes the water prison. "We shot myriad water elements," said Richardson, "water spinning and moving, collapsing and hitting the ground. We shot more single elements for visual effects than we have done on the previous four films put together!"

To generate water rising from the fountain and surrounding Voldemort, MPC employed Flowline water simulations with a new dynamic rendering engine to ray-trace large liquid volumes. "We wanted to enable MPC to create a real three-dimensional fluid, not just a rotating sphere," commented Stephan Trojansky. "It was a zero-g effect, like when astronauts on the space shuttle pour out Coke in midair and it clumps together purely from surface tension. We simulated that by eliminating classic downward forces on the liquid simulation, then collected liquid in a central point, keeping it together as a large object that reacted to streams of water circling around it."

MPC combined CG water with practical elements and created interactions using collision geometries of the fountain and Voldemort matchmoved to the plate. "Some shots were a little heavier 2D versus 3D," related Greg Butler. "When Voldemort is trapped in the bubble and Dumbledore moves him across the environment, the bottom of the bubble was a mixture of 3D and 2D drips from the plexiglass bubble shoot. When the bubble bursts, it was primarily a 2D element from the dump tank shoot. Almost all of our water shots contained some amount of Flowline-generated water."

Freed from his water prison, Voldemort unleashes a blast of energy that shatters Ministry of Magic office windows, and then flings glass shards at Dumbledore. Physical effects fabricated 240 curved plexiglass breakaway windows for the explosion, and shattered panes above the set using an array of air mortars. MPC extended exploding offices using dynamic simulations of shattering CG windows generated by its proprietary rigid body dynamics system, PAPI, within Maya. “We matched practical bursting windows to enhance initial window explosions and then continued the effect into full CG shots,” said Butler. “For shots of Voldemort gathering the glass and sending it in an attack formation at Dumbledore, we used expression-based particles with glass instanced onto them, and then flew those towards Dumbledore.”

Dumbledore defends himself by grinding glass to sand. MPC created glass-to-sand transitions by marking a 3D line through the scene. When flying glass shards met the shield, the leading edge of each shard generated a stream of particles. Sandy particles then impacted with collision objects representing Dumbledore and Harry.

The film concludes with Harry saved and the Ministry of Magic forced to face Voldemort’s return. The epic production contained, after cosmetic fixes and incidental effects, approximately 1,600 visual effects shots, a statistic on par with the previous film. The experience led Yates to resume the director’s role for the sixth Potter film. “We’ve just started work on *Harry Potter and the Half-Blood Prince*,” concluded Tim Burke. “After five films, it’s been a great education. We’ve learned how to produce and create visual effects fairly efficiently, but I’ve also learned that having fun with the work is important. *Harry Potter* films are such big productions, you always have to ask everyone to go the extra yard, and it helps if you keep up motivation. David did that on this film, and I think it shows on screen. Having happy crews is the best way to make good films.”

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